speciesaction
FRAMEWORK

HANDBOOK
Species management in Scotland

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad
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How to use this handbook

This handbook summarises the knowledge and experience gained during the programme of work in Scotland embraced by the Species Action Framework (SAF). We have also included updates of action taken since SAF finished. Most of the work focused on targeted management required for species conservation and invasive non-native species control. By making the details available to practitioners in particular, and a wider audience, we hope to bring enduring benefits for wildlife featured here and more widely.

This handbook documents our work on 32 species. We have also published the species and introductory chapters separately on the SAF web pages – these have smaller file sizes and are therefore easier to download. In fact we published most of these individual species accounts previously as and when they were ready, and you will see that the publication dates for many of them are from before 2016. However, we have now pulled them all together in one place for this handbook. The SAF web pages will also take you to the presentations and posters on the SAF species projects given at the SAF conference in 2012.

We have used embedded hyperlinks throughout this digital document that link to the websites of partner organisations, other key publications and the email addresses of authors. Inevitably some of the links will change over time, so please let us know if you notice any which no longer work (you can do this by using the comments option at the bottom of each web page).

We hope you find this handbook useful – please tell your colleagues about it.

Acknowledgements

We thank the many authors of the chapters published in this book, together with the reviewers who also contributed to the final versions. We thank the numerous contributors to the species projects run during the SAF – including the SNH Species Leads and members of the SNH Management Group, the staff based in the numerous partner organisations (we have tried to list these in our introductory chapter), and the land managers, volunteers, administrative staff and others who all played such a vital role. Many of the key individuals are named in the acknowledgement sections of each of the chapters. Thanks also go to Ian Kirkwood, the supremely patient designer of the handbook.
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An introduction to the Species Action Framework

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Summary

- This introduction to the Species Action Framework (SAF) explains the underlying rationale and how we selected 32 species for targeted action.
- Four categories were adopted for brigading species: species conservation; invasive non-native species; conflicts of interest involving native species; and sustainable use of species.
- SAF marked a new approach to species conservation and management. Resources were directed at strategically planned and targeted management action for a limited number of species but with a wide biodiversity benefit. It relied on the involvement and leadership of effective partnerships.
- The overall success of the work is outlined, with pointers to further work needed.

Introduction

The Species Action Framework (SAF) was devised to ensure that limited resources could make a real difference for Scotland’s species and wider biodiversity. Targeted management focused on 32 species over a five-year period between 2007 and 2012, with much work continuing to date. Scottish Natural Heritage (SNH) coordinated the process but by the end of SAF almost 100 partner organisations were involved, together with over a thousand volunteers, and many land managers, farmers, academics and others.

Some of Scotland’s recent, high profile species projects came under the SAF banner, for example:
- Saving Scotland’s Red Squirrels
- East Scotland Sea Eagle Project
- Scottish Beaver Trial
- Cairngorms Wildcat Project
- Scottish Mink Initiative
- Langholm Moor Demonstration Project.

Much of the project work involved species with fur and feathers. The Cairngorms Wildcat Project went on to become a winner at the Nature of Scotland Awards in 2013, with the Scottish Beaver Trial a runner-up (both in the ‘Innovation Award’ category). But there was also exciting work done for a lot of species that do not always get the publicity they deserve, such as woolly willow, great yellow bumblebee or hazel gloves fungus. There was well-deserved recognition for the SAF-supported work on the marsh fritillary butterfly with another win at the Nature of Scotland Awards in 2015, and the Cairngorms Rare Plants Project was shortlisted in 2014 (both in the ‘RSPB Species Champion Award’ category).

The wide range in the taxa covered by SAF was reflected by the breadth and reach of work done, from getting agreements for international flyway plans covering thousands of miles for Greenland white-fronted goose, to cutting up tree stumps within small habitat patches to help pine hoverflies. For some species the aim was to control them rather than conserve them, with actions such as the targeted management of invasive rhododendrons in areas of high biodiversity value, and testing methods to deal with New Zealand pygmyweed.

Since completion of most of the project work we have been passing on the experiences and lessons learned. Research, survey and monitoring projects tend to be well recorded, but this is not always the case with management work. We therefore organised a conference dedicated to SAF in late 2012, and produced posters for each of the 32 species; these are available, together with podcasts of the speakers and their Powerpoint presentations, on the SAF pages of our website. However, we also wanted to produce a Handbook written by those who led on much of the work. This publication is the end result and we hope you find the content interesting, useful and inspiring.

Background to the Species Action Framework

The SAF was produced in response to the 2004 Scottish Biodiversity Strategy (Scottish Executive, 2004) which set out what we all needed to do over 25 years to conserve and enhance biodiversity. The importance of Scotland’s biodiversity to our health, individually and as a nation, was emphasised in the Strategy, together with its enormous economic value. These values have continued to be recognised in subsequent revisions of the Scottish Biodiversity Strategy (including Scottish Government, 2013, 2015).

At SNH we realised the importance of setting priorities for the way we manage species, focusing on those where we might expect significant wider gains to biodiversity, and thereby benefits for people. The result was the SAF which, following consultation and discussions during 2006, received a ministerial launch in 2007. Full details are provided in the SAF document (SNH, 2007) (Fig.1), but in essence it set out a strategic approach to species management in Scotland, together with a list of 32 species for which new, focused effort and resources over five years could make the most difference for biodiversity. Ultimately our longer term aim for species management is to ensure that we have
thriving and, where possible, self-sustaining and self-regulating populations of native species, distributed throughout their native range.

We identified four main situations where species management is needed:

1. **Species conservation** – where a species needs targeted action to increase its range or population size because it is at risk in Scotland or internationally, or because it plays a vital role in achieving healthy ecosystems.

2. **Invasive non-native species** – where a species that is not native to a particular area threatens biodiversity aims.

3. **Conflicts of interest involving native species** – where the behaviour of a species brings it into conflict with people's interests or with the conservation of other species or habitats.

4. **Sustainable use of species** – where a species in the wild is a resource of social or economic benefit (e.g. field sports, fisheries).

The full criteria used for selecting the 32 species for targeted action are provided in the original SAF document (SNH, 2007). However all these species fell within at least one of the four situations above. It was also necessary for there to be sufficient knowledge of the species concerned to inform management work, and a consensus that targeted action would make a difference (for example if there was an identified management action likely to work and/or the species concerned was thought to have a key influence on ecosystem function).

Reintroduction candidates were also considered, but the proposals had to address the IUCN Guidelines (IUCN 1998). Note that since SAF finished these guidelines have been revised (IUCN, 2013) and a Scottish Code for Conservation Translocations with accompanying Scottish guidelines has been produced (National Species Reintroduction Forum, 2014).

The SAF also identified five broad principles on how we manage species for biodiversity. These should guide all species management:

1. Species management is a shared responsibility.
2. There are ecological and socio-economic aspects to species management decisions.
3. Species management benefits from a strategic approach.
4. Species management needs an adaptive approach.
5. Management activity should have regard to animal welfare.

These principles were applied to the work done for the 32 SAF species. It was widely acknowledged that practitioners of land and water management would be key partners in meeting the biodiversity conservation objectives for SAF.

**How we coordinated and resourced the Species Action Framework**

When SAF was launched in 2007 by the Government's Deputy Minister for Environment and Rural Development, Sarah Boyack MSP, she stated that ‘…SNH will now focus efforts and resources towards these target species…’ and that we should work ‘…in partnership with other bodies…’. To get things started we therefore set up a project and worked out how our own staff could support the process. We identified key individuals within SNH - an ‘SNH Species Lead’ for every species on the list and an overall SAF Project Manager to coordinate the process.

The SNH Species Leads acted as contact points and, working with partners, ensured that efforts concentrated on targeted management action - getting work done on the ground.

We also set up a small project management group within SNH to assess funding bids and ensure that the five broad principles of species management (listed above) were applied. For example, we received a number of proposals for mink management projects, but made a point of prioritising our limited resources on encouraging large scale, strategically planned projects (in northern Scotland or west coast islands) that built on well designed, existing work that were ‘future-proofed’ as much as possible.

This simple operational approach was designed to keep the bureaucracy and paperwork to a minimum, ensuring that decisions were made and funds released as quickly as possible, and that resources were targeted at getting the work done.
On the whole, with some inevitable exceptions, this seemed to work well and it received generally positive feedback from our partners (Park, 2014).

As well as providing staff to support the work, we also provided funds. In total, approximately £4m was provided by SNH over the five years of SAF (an average of £800,000 per year). This worked out at an average of around £25,000 spent per species per year, although there was considerable variation across species. These figures exclude expenditure on native deer, which are listed on SAF, because a large programme of work with funding from existing budgets was already directed at these species.

The SNH funding was directed at targeted management work, in line with the ethos of SAF. However there was also some additional funding for associated research, including three SNH PhD studentships (on signal crayfish, hazel glove fungus and pine hree), and for national curriculum educational material, publications and web outputs.

This commitment of SNH funding and support was intended to provide sufficient influence for our partners to ‘lever’ funds, sometimes very considerable, from other sources. There were some good examples of where this worked, with the early SNH commitment going some way in helping to obtain substantial additional funds for the mink projects, the Langholm Moor Demonstration Project (dealing with hen harriers) and the Scottish Beaver Trial.

But of course the SNH contribution was just a part of the SAF process. The many partnerships formed for the different species projects were absolutely crucial, and underpinned the whole process. We estimate that at least 94 different organisations were involved in SAF at some point. The list at the end of this chapter shows the wide range, covering the land use and conservation sectors, public bodies and NGOs, and funding and commercial sponsoring partners. On top of this were the many individuals who had essential roles - the land owners and farmers, specialists and volunteers. Overall SAF became one of the biggest multi-partner initiatives that SNH has been involved with.

It is very difficult to work out the overall resource contributions from the partners over the five years, but it was probably at least £4.9m, on top of many other ‘in kind’ resources of one type or another.

Another key potential source of funding was the Scottish Rural Development Programme (SRDP), and in particular the ‘Rural Priorities’ scheme. This is the main agri-environment incentive scheme that operates in Scotland, funded through Scottish Government. The first phase of SRDP was launched about a year or so after SAF started (a second phase of SRDP was subsequently launched to cover 2014-2020) and it changed the way we had to do things. For example, types of management work which could be funded by SRDP could no longer be funded directly by SNH SAF funds.

Once SRDP started it was clear that if we could work out how to use the potential of SRDP, then it might achieve far more than SAF funding ever could by itself. Therefore SAF was specifically identified as a Rural Priority when SRDP was launched. SAF funds were then used to support some project officer posts – these had the role of trying to work out where to target efforts, and of providing expert advice to farmers and their agents to try and ensure that opportunities for SAF species were included in their SRDP applications.

Project officer posts were established for species such as the SAF butterflies and moths, great crested newt, capercaillie and rhododendron. Although the complexity of some of the SRDP application process could be off-putting for land managers, particularly for small sites, we found that the use of project officers often played an important role in helping to smooth the process. Experiences varied in how well SRDP could be used to support certain actions – supporting grazing management for species such marsh fritillary butterfly proved to be effective, but it was more difficult to organise support for pond creation work for great crested newt. These useful experiences were passed on to those planning the second, 2014-2020 phase of SRDP.

It is difficult to extract the funding directed at SAF projects from SRDP statistics, because there is much overlap between SAF objectives and wider biodiversity objectives. But we can say that £4.7m was awarded between April 2008 and March 2012 to support ‘viable populations of rare or endangered species’, some of which would have been for SAF species identified as a Rural Priority (with additional funding for invasive non-native management work).

How did the Species Action Framework perform?

To answer this question we urge you to read the chapters! Hopefully there are lessons here that will be of interest to many practitioners, land managers and policy makers.

After SAF finished we carried out a consultation exercise with staff based in SNH and our external partners who had led on much of the SAF work. They provided useful feedback on which elements of SAF they thought worked best, and where things could have been done better. It is available on the SNH website (Park, 2014).
Clearly the key objectives for the SAF work were about the biodiversity benefits we were trying to achieve. For some of the species we can point to clear and measurable outcomes, for example the numbers of an animal or plant successfully translocated to a new site. But for some of the work done over the five years, it may take a while to see how successful it has been in terms of improving the conservation status of a species, or controlling an invasive non-native species. We already have examples of promising short-term results for some species (for example following the translocations of woolly willow, vendace and white-tailed eagle), but their longer-term viability will require further monitoring. Freshwater pearl mussels, to pick another example, can have a life span of over a hundred years, and it may take decades for the results of conservation actions to become clear.

There have also been some species for which we have not been able to address all of our original aims. For example, initially it was thought that it might be possible to control wireweed, a marine invasive non-native seaweed from the western Pacific, and prevent its further spread. However the results of a survey, which included reports sent in by members of the public, found that it was more widespread than originally thought. It became clear that eradication from Scotland is not possible using current techniques, and that further expansion cannot be prevented. Nevertheless, the work highlighted the role of awareness-raising campaigns, modelling techniques for predicting occurrence, and the need to focus action on preventing the introduction of marine non-native species, in collaboration with other countries.

**Some broad conclusions**

A few conclusions can be drawn already:

1. SAF shifted the focus of a lot of our species work to more targeted management action. Previously this had not always been given enough focus compared with, for example, research, survey and monitoring. All these are vital of course, and they all support management, but getting the work done on the ground is ultimately how we can make a positive difference to biodiversity.

2. SAF provided a demonstration of the vast range of management action types needed to get the work done. There is no ‘one-size-fits-all’ solution for the management of these varied species. Examples of types of action are:
   - Habitat and land use management (e.g. grassland, woodland, moorland).
   - The conservation translocation of species, at a national scale or at smaller catchment and habitat-patch scales (e.g. white-tailed eagles to eastern Scotland, pine hoverflies within a forest).
   - Demonstration projects to test methods and provide opportunities for practitioners to visit and learn (e.g. Langholm Moor Demonstration Project, great-yellow bumblebee demonstration sites).
   - A range of very species-specific measures, such as marking fence lines for capercaillie, and making egg-laying sites for pine hoverflies in tree stumps.
   - Dealing with specific non-native species or genetic forms that pose a threat to SAF species (e.g. mink, which threaten water vole; grey squirrels, which threaten red squirrels; domestic/feral cats in the Cairngorms, which hybridize with wildcat).
   - Strategic coordination of invasive non-native species work at large geographic scales, and ‘future-proofing’ projects to avoid wasted effort and re-invasion of species once resources are reduced (e.g. the Scottish Mink Initiative).
   - Cooperation at international levels, such as flyway planning for Greenland white-fronted goose.
   - The use of various communication tools to support all of the above.

3. The five-year SAF programme covered a relatively long period by the usual public-body standards. SNH was able to commit resources at the outset, which meant that people were able to plan ahead, and build a momentum with the work. For example, the colossal rhododendron issue needed time to develop an effective approach.

4. SAF provided an opportunity to try out new techniques and to take risks. Examples included the construction of physical barriers to prevent signal crayfish spread, and trying to work out how to breed pine hoverflies in captivity.

5. There was also a ‘legacy’ from SAF. In some cases SAF helped to test methods, carry out initial groundwork, develop partnerships and demonstrate the commitment and enthusiasm of the parties involved. This helped to get new phases of species work underway after SAF finished. A few examples are given at the end of this introduction. It also helped SNH to develop its Wildlife Management Framework.
which was designed to ensure decisions on wildlife management are consistent, informed, proportionate, practical and cost effective. The Wildlife Management Framework sets out how and why SNH gets involved with, and makes decisions on, wildlife management.

**Wider species, habitat and ecosystem benefits**

Early on there were some criticisms that SAF represented a reversion to an old style of species-driven conservation, and that this did not appear to fit in with the wider habitat/ecosystem approach that many were trying to encourage. In fact SAF very specifically targeted species where the wider ecosystem-led approaches to management were unlikely to work. But it is also important to emphasise that the management actions for each SAF species often had many wider benefits:

- In some cases the SAF species were ‘symbolic’ or ‘totemic’ flag-bearers to communicate messages and promote much broader issues about biodiversity conservation e.g. hazel gloves fungus which was used to promote Atlantic hazelwoods and their management.
- There were often management actions directed at one species that benefited many others, e.g. pond creation for great crested newt benefits a wide range of pond life.
- Some species have a ‘keystone-type’ role and can provide wider ecosystem benefits e.g. pollinating species such as great yellow bumblebee.
- Action taken on a single invasive non-native species can reduce threats to wider biodiversity e.g. *Rhododendron ponticum*, which causes so much damage to the native flora of our special west coast woodlands.

These are all examples of how a targeted, ‘species-type’ approach can have much wider benefits. Species projects are often of particular interest to the wider public, and this can be used to promote and demonstrate wider biodiversity objectives.

**Socio-economic benefits**

We can also look beyond the biodiversity benefits at some of the socio-economic benefits.

There was significant commitment and engagement by many individuals during SAF. We are aware of over 1000 volunteers being involved in various SAF-funded projects over the five years. In addition there were many others who sent in records in response to specific publicised surveys, such as for lesser butterfly-orchid, wireweed, and squirrels for the *Saving Scotland’s Red Squirrels* Project.

There were also more direct economic impacts. Although this was not assessed in any detail, we believe over 45 jobs were directly linked to SAF-funded work, many of these based in rural areas. These were often project officer-type posts based at one of our partner bodies. In addition there were more short-term contracts, ranging from digger drivers creating ponds, to academics modelling mink populations to help target trapping (this excludes those associated with deer management, which is a significant work sector itself).

Species projects therefore not only benefit targeted species and/or wider biodiversity, but also the types of ‘cultural ecosystem services’ and other socio-economic values that government, and indeed much of the public, supports (for example health and well-being, promoting access to the countryside, Citizen Science, and contributing to rural economies).

**The next steps**

Many people have asked whether there will be a second, similar exercise to SAF. That is a question for which there is currently no clear answer, although the end of SAF marked a new phase for many ongoing or new projects for SAF species. Most of these are highlighted in the following species chapters, but they include:

- **Freshwater pearl mussel** - Catchment-scale management plans produced during SAF led to the subsequent *Pearls in Peril* LIFE+ project that will run until 2016, and has a budget of £3.5 million.
- **Scottish wildcat** – Measures trialled during the Cairngorm Wildcat Project supported by SAF were reviewed and developed for *Scottish Wildcat Action*, a partnership project supported by the Scottish Government and Heritage Lottery Fund.
- **Eurasian beaver** – The *Scottish Beaver Trial* continued after the end of SAF, with monitoring finishing in May 2014. The results of this were included in the final *Beavers in Scotland* report (Gaywood, 2015) submitted to Scottish Government in June 2015. In November 2016 the decision was made to allow beavers to remain, representing the first ever formal reintroduction of a mammal species anywhere in Britain.
• Woolly willow – The planting of young willow plants has continued at a number of Scottish sites through the support of partner organisations and individuals.

• Hen harrier – The Langholm Moor Demonstration Project continues to be supported by partners, and the final report is due by the end of 2017.

With growing pressures on resources there is an ever greater need to prioritise and focus work. Projects involving translocations are now developing a more planned and strategic approach through the work of the National Species Reintroduction Forum and the Wildlife and Natural Environment Act (2011) has meant stronger legislation and guidance is now in place for invasive non-native species. SNH’s Wildlife Management Framework is helping to guide decision making on wildlife management, and the Scottish Biodiversity Strategy Route Map to 2020 (Scottish Government, 2015) sets out an aim to ‘deliver focused action for priority species in Scotland’. The last of these identifies some specific ongoing and planned projects, and notes that a further suite of projects is to be developed.

The SAF has been a great success, and those involved should be justly proud of their work. Significant challenges remain of course. We therefore hope that new work will be guided, informed and inspired by the experiences of the many practitioners recorded in this Handbook.

References


The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.


Partner organisations involved in SAF projects

(with apologies to any that may have been missed).

Agrimony
ALP
Amphibian and Reptile Conservation Trust
Argyll and Bute Council
Argyll and the Islands SRDP LEADER
Association of Scottish Shellfish Growers
Botanical Society of Britain and Ireland
British Dragonfly Society
Buccleuch Group
Bumblebee Conservation Trust
Burnet Study Group
Butterfly Conservation
Cairngorms National Park Authority
Cairngorms Rare Plants Project
Centre for Ecology and Hydrology
Clyde River Foundation
Countryside Council for Wales
Derek Gow Consultancy
Edinburgh Biodiversity Partnership
Environment Agency
Fish Conservation Centre
Forest Research
Forestry Commission Scotland
Game and Wildlife Conservation Trust
GDF Suez
Greenland White-fronted Goose Study
Herriot Watt University
Highland Biodiversity
Highland Birchwoods
Highland Council
Historic Scotland
Hymettus
Joint Nature Conservation Committee
Kilgarth Development Company
Leader Programme
Life Nature Fund
Loch Lomond and Trossachs National Park
Lochaber Fisheries Trust
Lothian Amphibian and Reptile Group
Malloch Society
Marine Scotland Science
Midlothian Council
Montane Scrub Action Group
Moredun Research Institute
North Atlantic Fisheries College
National Museum of Scotland
National Trust for Scotland
National Wildlife Crime Unit
Native Woods Cooperative (Scotland)
Natural England
People's Trust for Endangered Species
Plantlife
Queens University Belfast
Red Squirrel Survival Trust
River Annan Trust
Rivers and Fisheries Trusts of Scotland
Rothiemurchus Estate
Royal Botanic Garden Edinburgh
Royal Society for the Protection of Birds
Royal Zoological Society of Scotland
SCENE Loch Lomond
Scottish Agricultural College
Scottish Aquaculture Research Forum
Scottish Association for Marine Science
Scottish Environmental Protection Agency
Scottish Gamekeepers Association
Scottish Government
Scottish Land and Estates
Scottish Native Woods
Scottish Natural Heritage
Scottish Power Renewables
Scottish Venison
Scottish Water
Scottish Wildlife Trust
Shellfish Association of Great Britain
South Lanarkshire Council
Scottish Rural Property and Business Association
The British Lichen Society
The Crown Estate
The Falkirk Area Biodiversity Partnership
The Farm Environment
The James Hutton Institute
The Royal (Dick) School of Veterinary Studies
Tubney Trust
Tweed Forum
UACPA Ltd
University Marine Biological Station Millport
University of Aberdeen
University of Chester
University of Glasgow
University of Stirling
Veterinary Laboratory Agency
West Lothian Council
University of Oxford WILDCRU
Wildlife and Wetlands Trust
Species conservation

We identified ‘species conservation’ as the first situation under SAF where species management is appropriate to benefit nature. This category embraced the majority of the SAF species. Here, we sought targeted action focused on a species to increase its range or population size because it is at risk in Scotland or internationally, or it plays a vital role in supporting healthy ecosystems.

Actions included specific habitat measures, efforts to reduce the adverse impacts of human activities (such as through enforcement of legislation, or voluntary agreements), trying to change human behaviour through education, or conservation translocations.

Twenty-two out of the 32 SAF species fell within this category. These became the focus of new, targeted effort and resources over the five year project. Twenty of them met the SAF criterion of being ‘native species that are critically endangered in Scotland or elsewhere, or demonstrating significant decline, or for which Scotland is a stronghold (including species that are only found here, i.e. endemic), and there is a continuing threat to the species in the immediate future.’ In addition, beaver and white-tailed eagle were selected because they met the SAF criterion of being ‘formerly native species now extinct in the UK, whose international conservation status could be improved by reintroduction to Scotland or which could play a significant role in enhancing ecosystem health and resilience.’

All the relevant species are listed below.

**Vertebrates**
- Black grouse
- Capercaillie
- Eurasian beaver
- Great crested newt
- Greenland white-fronted goose
- Red and grey squirrels
- Scottish wildcat
- Vendace

**Invertebrates**
- Water vole
- White-tailed eagle

**Plants and fungi**
- Freshwater pearl mussel
- Great yellow bumblebee
- Marsh fritillary butterfly
- Pearl-bordered fritillary butterfly
- Pine hoverfly
- Slender scotch burnet moth
- Bird’s-nest stonewort
- Intermediate wintergreen
- Lesser butterfly-orchid
- Small cow-wheat
- Woolly willow
- Hazel gloves fungus
Capercaillie

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Summary

- **Conservation status** – the capercaillie remains vulnerable in Scotland with an estimated population size of 1,285 individuals, 75% of which are within the region of Badenoch and Strathspey.

- **Targeted management** – the Species Action Framework (SAF) Implementation Plan targeted management in key parts of the capercaillie range.

- **Reduce chick mortality** – predator control was targeted around leks in order to reduce chick mortality.

- **Increase adult survival** – capercaillie mortality is reduced when high risk deer fences are marked or removed.

- **Create and enhance brood habitats** – brood habitat can be improved by early and variable-density thinning of plantations, drain-blocking, heather-cutting and repairing stock fences to exclude livestock.

Why was this species on the Species Action Framework list?

It satisfied criterion 1a of the SAF as a species for conservation action (Scottish Natural Heritage, 2007). The breeding population had declined considerably over the previous 25 years. Knowledge of the general ecology of the species was good (although some further research is needed). Work undertaken through an earlier LIFE project showed that capercaillie thrive best in connected areas of suitably managed habitats with predator control and where deer fences have been removed or marked.

The capercaillie was identified as a UK Biodiversity Action Plan (UKBAP) Priority Species and is on the Scottish Biodiversity List. It is listed on Annex I of the EC Birds Directive and is fully protected under the Wildlife and Countryside Act 1981, as amended (listed in Schedule 1). It is a high-profile species, and a ‘capercail’ hide has been set up at Loch Garten RSPB reserve to allow the public to view lekking birds.

Introduction

**Species background**

The capercaillie (Tetrao urogallus) is a large grouse of open mature pinewoods (Fig. 1) and plantations. Males (cocks) have a slate-grey plumage, with a blue sheen over the head, neck and breast, reddish-brown upper wings with a white shoulder flash which becomes prominent during display, a bright red eye ring, and long, rounded tail. Females (hens) are brown with a dark chestnut-red, fan-shaped tail and an orange-rufous patch on the throat.

Habitat, distribution and abundance

The global population extends throughout the forests of mountainous and boreal regions of Scandinavia, central Europe, northern Asia and Siberia (Storch, 2001). The European breeding population is large (over 760,000 pairs), with notable populations in Russia and Scandinavia (Birdlife International, 2012). The UK range is localised and centred on Badenoch and Strathspey but extends south and west to the woodlands in Perthshire, as well as northwards into Ross-shire.

The Scottish population is found mainly in Scots pinewoods, in particular Caledonian Forest with dense ground cover of blaeberry (Vaccinium myrtillus) and heather (Calluna vulgaris) (Fig. 2), but will also use mixed conifer plantations (Watson and Moss, 2008). Capercaillie also require areas of blaeberry and bogs providing a good source of insects for chick feeding. Dense areas of young trees and unthinned plantation areas provide additional shelter in bad weather and cover from predators.
**General ecology**

Adult birds feed on blaeberry from early spring through to summer, as well as plant buds, pollen cones, flowers and seeds, with conifer needles being eaten primarily in winter (Storch, 2001). Females require a high protein diet when they lay eggs. In spring, hens are often associated with forest bogs, where they feed on cotton grass (*Eriophorum* spp.) shoots, and stands of larch (*Larix* spp.), where they feed on buds and flowers (Watson and Moss, 2008). Invertebrates, particularly caterpillars associated with blaeberry, form a large part of the chicks’ diet in their first month. Broods can use areas of 60 ha or more. Such areas must contain food, cover and places to dry out (Storch, 1994; Kortland, 2006). Males attend leks (traditional display sites) in open areas of woodland during spring. Females lay 5-12 eggs in a nest on the ground. Incubation takes 26-29 days and chicks leave the nest very soon after hatching (Storch, 2001). They remain with the hen through the summer and fledge from late August.

**History of decline, contributory factors and current threats**

Since 1994, the capercaillie population in Scotland has fluctuated between 1,000 and 2,000 individuals. The last national estimate was of 1,285 individuals (95% confidence interval: 822-1882). 75% of birds are located in Badenoch and Strathspey, with smaller and rapidly declining populations in Easter Ross, Moray and Nairn, Deeside and Donside, and Perthshire (Ewing et al., 2012).

Although the dramatic decline towards extinction may have been halted, or at least slowed, the capercaillie remains one of Britain’s most threatened species. In the last decade, capercaillie have all but disappeared from parts of southern Perthshire and areas west of the Great Glen. In many areas, capercaillie have retreated to a few key strongholds. Our aim has to be a robust population that can withstand natural predation and losses due to accidents and poor weather. A number of possible causes of the decline are listed below:

- Low productivity due to climate and weather affecting the breeding condition of hens and chick survival.
- Predation, including by foxes and crows, pine martens and raptors.
- Collisions with deer fences.
- Limited brood habitat due to fragmentation and issues with grazing management.
- Human disturbance, in part due to forestry operations and recreation.

**Aims**

**Aims for 2007-2012**

- Reduce capercaillie mortality caused by fence collisions by marking or removing high risk deer fences.
- Increasing capercaillie productivity by creating or enhancing capercaillie brood habitat.
- Promote ‘capercaillie-friendly’ land management practices through uptake of Rural Development Contracts.
- Reduce chick mortality by targeting site-specific predator control.
- Promote capercaillie-friendly land management practices by continuing to incorporate suitable measures into National Forest Estate Forest Design Plans and encouraging their incorporation in private forest plans.
Management Action

Summary of work done

Action for capercaillie focused in three areas:

- **Private Estate Management** – The SAF project directly funded management on private ground. The following outputs were achieved:
  - Brood habitat enhanced over 900 ha by swiping 111 ha of heather to promote blaeberry, blocking drains, repairing 6,100 m of stock fence, and creating brood cover over approximately 400 ha by brash piling, enrichment planting and tree pulling.
  - Brood habitat created by variable-density thinning over 300 ha of plantations.
  - Mortality reduced by marking 14,050 m of deer fences and reducing 2,372 m to stock height.
  - **Capercaillie: a guide for management** – a promotional leaflet focused on the Scotland Rural Development Programme (SRDP) Capercaillie package.
  - A seminar for forest managers.

- **Scotland Rural Development Programme** – SRDP uptake was promoted by the project. Funding was allocated for predator control around 25 leks. Capercaillie management was incorporated into long-term Forest Plans. Additional management funded under the scheme included thinning and restructuring, stock fence repairs, heather swiping and fence marking. Native woodland creation occurred in strategic areas for capercaillie.

- **National Forest Estate** – Targeted management has been carried out on the National Forest Estate:
  - Habitat improvement over 6,258 ha.
  - Predator control over 11,817 ha.
  - 500 m of deer fence removed and 2000 m marked.
  - Capercaillie-friendly silviculture adopted over more than 10,000 ha of key capercaillie forests.
  - Monitoring of all leks.
  - Management of recreational activity.
  - Planning of forestry operations to avoid lekking capercaillie.

Management operations were restricted during the breeding season (1st March to late July) to avoid disturbance to breeding capercaillie, informed by guidance from the Capercaillie BAP Steering Group.

**Partnership working and resourcing**

Funding was directly provided by SNH via the Capercaillie SAF Steering Committee (representatives of SNH, Forestry Commission Scotland (FCS), RSPB, the project administrator Highland Birchwoods and the Capercaillie Project Officer). Potential works were identified by the Capercaillie Project Officer, prioritised by the Steering Committee and delivered through liaison between the project administrator, Capercaillie Project Officer and the estate Forest Manager. Visits before, during and after management were undertaken by the Capercaillie Project Officer on behalf of the Steering Committee. Progress reports were provided to the Capercaillie Biodiversity Action Plan (BAP) Steering Group at their meetings.

Below is a summary of the main legislative, policy and strategic approaches developed during the lifetime of the SAF project.

**Reducing mortality - marking deer fences**

**Site description**

This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and lies on the boundary of a Special Protection Area (SPA) for capercaillie. The deer fence protects regeneration within a Caledonian pinewood Special Area of Conservation (SAC) from the impacts of deer browsing. The fence bisects open ground between the designated ground and a non-designated plantation. In total, over 3,000 m of fencing was marked on the boundary of the SPA.

**Methods and results**

Deer fences can present a significant threat to capercaillie, particularly where they occur within existing woodlands. The Forestry Commission has published guidance on the correct method for marking a fence within Capercaillie Core Areas. In this case, UV-stable orange barrier netting was attached to the fence (Fig. 4). Evidence shows
that the number of cocks visiting leks increases or remains stable when deer fences have been marked, comparing favourably to areas where deer fences remain unmarked (Kortland, 2008).

Reducing mortality - reducing deer fence to stock height

Site description

This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and lies adjacent to an SPA for capercaillie. It is a Scots pine (*Pinus sylvestris*) plantation with smaller blocks of broadleaves and exotic conifers. Suitable ground vegetation covered much of the site, making it attractive breeding habitat for capercaillie. An internal deer fence that was a significant threat bisected the site, cutting through open, boggy forest habitat used by capercaillie.

Methods and results

It was not possible to remove the fence so the top netting was taken away and the fence posts were cut. This reduced it to the height of a stock fence (Fig. 5). Remaining materials were removed from the site. This action reduced the risks of mortality in this woodland.
Creating brood habitat - variable density thinning

Site description

This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and lies immediately adjacent to an SPA for capercaillie. The wider area consists of mixed conifer plantation and Caledonian pinewood. The upper slopes of the plantation consisted of Scots pine planted on rocky knolls, ledges and hollows. Variable density thinning would help to develop stand stability and crown depth in the retained trees.

Methods and results

Timber could not be recovered so chainsaw operators were used. 40-50% of stems were removed by expanding existing clearings around patches of blaeberry, wet flushes and rocky knolls. Elsewhere clearings were created around dominant trees to promote crown development and stability. To provide greater diversity and cover, 20% of the area remained unthinned in blocks of 0.1 to 0.25 ha. Felled trees had their branches removed and were left in contact with the ground. Care was taken not to smother ground flora and brash was piled as cover for broods.

A more diverse and sustainable area of habitat was created during this operation (Figs. 6a and 6b). The objective was to provide all the feeding and sheltering needs of capercaillie broods in a fine-grained mosaic and at a scale that fits their ranging capabilities. Unthinned stands and piles of brash provide cover and shelter for chicks.
Creating brood habitat - uneconomic thinning

Site description
This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and lies immediately adjacent to an SPA for capercaillie. Management was targeted at 54 ha of unthinned Scots pine and spruce planted in 1963. The crop was not thinned during the normal thinning window because slow growth had prevented economic harvesting and access was difficult. Blaeberry was present but sparse. Capercaillie leks surround the area but there was no evidence of capercaillie use of these woodlands.

Methods and results
This area was thinned by conventional harvesters so that timber could be extracted. Access racks were cut at 13–16 m intervals. Distances between racks were varied, where possible and safe to do so, to minimise the creation of a regular pattern. Existing gaps were expanded to create a more diverse structure in what was previously a uniform stand. Thinning favoured the Scots pine component of the crop, with spruce being retained as cover (Fig. 7).

Increased light levels derived from variable thinning produced rapid expansion of blaeberry. In the longer term, improved stability in the stand will enable long-term retention and the development of dominant trees will provide roost sites for capercaillie.

Creating and enhancing brood habitat - restructuring plantations by pulling over trees

Site description
This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and within an SPA for capercaillie. The area targeted for management was unthinned planted Scots pine where light levels were below optimum for blaeberry.

Methods and results
Rather than use conventional methods, a tractor and winch pulled over selected trees to create canopy gaps. This exposed root plates, created grit beds and gave easy access to young pine shoots, while protecting fragile pinewood soils (Fig. 8). This work created a mosaic of thinned and unthinned stands, interspersed with small glades and improved light conditions for blaeberry.

Fig 7. Compartment during thinning. Note the retention of spruce trees that will provide cover for broods. © Timothy Poole, RSPB

Fig 8. Tree pulled over exposing root plate to provide grit and crown to provide cover for broods. © James Gordon, RSPB
Enhancing brood habitat - drain blocking

**Site description**
This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and within an SPA for capercaillie. Historically, this area was drained by digging deep ditches to assist with tree establishment. Poor accessibility meant that trees were no longer harvestable resulting in the area becoming a natural reserve on the estate. The ground vegetation was dominated by heather and rushes (Juncus species).

**Methods and results**
Three dams were constructed at approximately 50 m intervals along a wide drainage ditch (Fig. 9a). Logs were cut to the width of the drain and placed in a pile. In order to ensure a snug fit, turfs and brash were fitted around the logs. Debris flowing along the drain will increase the size of the dam over time. The raised water table created a more diverse vegetation layer, including cotton grass, which provides important habitats for hens in spring and foraging chicks (Fig. 9b).

Fig 9a. Dam in drain to increase water level and bog habitat.
© Timothy Poole, RSPB

Fig 9b. Habitat in 2012 after drains were blocked in 2009.
© Rebekah Mayhew, RSPB

Enhancing brood and hen habitats - felling exotic conifers on a bog

**Site description**
This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and within dispersal distance of an SPA for capercaillie. Slow growing lodgepole pine (Pinus contorta) had been planted on a bog surrounded by stands of Scots and lodgepole pine. The bog is an important feature for hens in spring, whose presence had attracted lekking cocks.

**Methods and results**
All trees on the bog less than 15 cm diameter at breast height were felled by chainsaws. The aim was to create an open bog with scattered trees. Felled trees and brash were deposited in existing drains. Stands of lodgepole pine on the edge of the bog were thinned and racks created to create linkage with stands of thinned Scots pine. The operation enhanced the bog and prevented it from drying up. Additional thinning improved and created linkages between adjacent habitats (Fig. 10).
Fig 10. The operation improved the quality of habitat for capercaillie broods by increasing vegetation diversity and providing linkage to other patches of brood habitat. © Timothy Poole, 2012, RSPB

Enhancing brood habitat - stock fence repair

Site description

This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and adjacent to an SPA for capercaillie. This is a productive plantation of predominantly Scots pine with a heather and blaeberry field layer. The forest is surrounded on three sides by livestock grazing. In places, the external stock fence was in a poor state of repair so sheep incursions were frequent. Damage to important floral communities and tree regeneration were having a negative impact on capercaillie habitats.

Methods and results

The exact specification of the repair was dependent upon the contractor’s recommendations and the state of disrepair of the fence. Conventional stock fencing consists of stobs placed at intervals of no more than 3.5 m centres with a minimum of 6-line wires or 2-line wires and woven wire netting. If a high tensile pattern fence was erected, the same requirements applied to the number of line wires or netting but stobs were placed at up to 12 m centres (Fig. 11a).

The repair to the fence reduced the grazing pressure on the ground flora, which improved in height and cover (Fig. 11b).

Fig 11a. Replacement stock fence on edge of forest. © Timothy Poole, RSPB

Fig 11b. Blaeberry habitat that has recovered height since stock fences were repaired in 2008. © Rebekah Mayhew

Enhancing brood habitat - enrichment planting

Site description

This site is in the Strathspey, Moray and Nairn Core Area (Fig. 3) and within dispersal distance of an SPA for capercaillie. This is a productive forest on a hill. Scots pine has been planted on the slopes leading to the summit of the hill. The field layer is a mosaic of heather, blaeberry and bog vegetation favoured by capercaillie but with very little cover.
Methods and results

The aim of this work was to provide cover for capercaillie. Norway spruce (Picea abies) was selected as a tree that is shade tolerant but is not as invasive as Sitka spruce (Picea sitchensis). Trees were planted in groups of about 20 in gaps in the canopy. Damage from deer browsing was accepted, as the aim was to provide low ground cover rather than good timber. However, it was anticipated that a few of the spruces in the centre of the clumps would grow vertically and will develop into roost trees in the long term.

The structure created should provide a more balanced habitat mosaic. However, the trees struggled because of roe deer (Capreolus capreolus) browsing (Fig. 12).

Fig 12. Norway spruces planted in Scots pine stand (see bottom right hand corner). The trees have struggled because of roe deer browsing.

© Timothy Poole, RSPB

Methods and results

Hand-held brush cutters were used because the ground was steep and rocky. This labour intensive technique allows the operators to be more targeted, selecting individual areas of heather to cut (Fig. 13). The field layer was broken up by cutting small, irregularly shaped patches (maximum 0.25 ha). The precise shape is likely to be determined by factors such as ease of access. Additional lines were cut to link swiped patches to other important features such as forest bogs for brood cover. Care was taken to avoid cutting regenerating pine, juniper or native broadleaved trees.

Early results showed that blaeberry rapidly recolonised areas after swiping. In open and flat sites, tractor-mounted swipes have been used.

Fig 13. Heather swiped to increase blaeberry cover.
© Timothy Poole, RSPB

Enhancing brood habitat - heather cutting - brush cutters

Site description

This site is in the Deeside and Donside Core Area (Fig. 3) and within an SPA for capercaillie. Management was targeted within a Caledonian pinewood enclosed by a marked deer fence. The heather was becoming old and rank and appeared to be suppressing blaeberry growth.

Reducing chick mortality - fox and crow control

Location

Generalist predators can affect capercaillie productivity in fragmented forest landscapes. Funding for legal control of red fox (Vulpes vulpes) and crows was made available for sites containing active leks or on adjoining sites where control would be complementary.

Methods and results

The preferred methods of fox control are shooting individuals at night using lamps or using packs of hounds to drive foxes to waiting guns. Alternatively,
during late spring and early summer, foxes can be shot at dens using a terrier to bolt them. It is important that the vixen and cubs are killed humanely. Snaring in capercaillie woods only took place in the immediate vicinity of middens, which were located in areas not used by capercaillie. Crows were controlled using Larsen traps (Fig. 14) and/or cage traps in April and May, or were shot. Effective predator control reduces the densities of foxes and crows during the breeding season, which reduces the levels of predation on capercaillie eggs and chicks.

Effective predator control reduces the densities of foxes and crows during the breeding season, which reduces the levels of predation on capercaillie eggs and chicks.

Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

• Targeting management – the SAF project enthused land managers, as funds were easily accessible and reduced bureaucracy, while work was highly targeted through site-specific advice.

• Partnership working – this type of partnership approach between government agencies, NGOs and land management sectors is best placed to deliver management on the ground.

• Timing of operations – in the early years of the project, contracts were issued late. This meant that managers were struggling to complete work before the capercaillie lek season began. In subsequent years, the Steering Committee became more efficient at delivering contracts so that work could begin from the beginning of September.

• Collaborative working – collaborative management at a landscape scale is increasingly important for capercaillie.

• Habitat fragmentation and forest expansion – one of the key issues to overcome is habitat fragmentation. Linking or expanding existing forest habitats will create more robust populations by reducing edge effects and mitigating against the effects of climate change.

• Similar management continues, supported by funding via the Scottish Rural Development Programme. Recommendations from a new Cairngorms Capercaillie Framework are being implemented, which aim to target future management at a landscape scale and reconcile conservation with development pressures and recreation.

Further Information


Capercaillie BAP Steering Group guidance: Avoiding disturbance of breeding capercaillie – guidance for land managers.


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Key Management Messages

- **Management should be multi-faceted** – the optimum approach for capercaillie management should consider ways to improve breeding success and reduce adult mortality.
- **Targeting management** – management should be targeted in woodlands with existing populations of capercaillie, or where there is a strong chance of colonisation by adjacent populations.
- **Forest management** – managing for capercaillie can be consistent with other forest management objectives through careful forest planning.
- **Habitat management** – this should be targeted where there are key components of brood habitat, such as blueberry or cotton grass, already present. Habitat management should consider how to enhance existing or create new areas of brood habitat.

References


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The SAF Partners

- Scottish Natural Heritage
- Royal Society for the Protection of Birds
- Highland Birchwoods
- Forestry Commission Scotland
The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to [www.snh.gov.uk/speciesactionframework](http://www.snh.gov.uk/speciesactionframework).

Black Grouse

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Summary

• **Background** – formerly widespread across Britain, black grouse (*Tetrao tetrix*) suffered a reduction in numbers and range throughout the 20th century. More recently, the Scottish population declined by 29% between 1995/96 and 2005. Habitat degradation, largely caused by agricultural intensification and forest maturation, alongside low survival rates, contributed towards these losses.

• **Objectives** – the Species Action Framework (SAF) black grouse project focused on stemming the decline in numbers and range and on increasing the size and range of the Scottish population.

• **Approach** – SAF funding was used to deliver black grouse projects throughout Scotland, in partnership with a range of contributing partners: Royal Society for the Protection of Birds (RSPB), Game and Wildlife Conservation Trust (GWCT), Forestry Commission Scotland (FCS), Scottish Power, and GDF Suez.

• **Achievements** – awareness of black grouse conservation was raised among practitioners through five workshops and the production of a conservation brochure. SAF funding of two black grouse recovery projects helped to facilitate 60 Rural Development Contracts of relevance to black grouse. It funded a fence marking/removal project to help to reduce bird fatalities and helped fund a seven-year forest management trial in Galloway Forest Park and Fort Augustus. More recently SAF funded two reviews examining the level of supporting evidence for various black grouse conservation techniques, and the extent and efficiency of existing/previous black grouse conservation work.

• **Conclusions and future recommendations** – conservation action was delivered through a number of different initiatives. Recognising the importance of partnership working we hope to improve black grouse monitoring, targeting of resources and conservation delivery across Scotland. RSPB, GWCT, FCS and SNH are currently developing some of these recommendations through the black grouse Scottish Biodiversity Action Plan group (SBAP).

Introduction

**Species background**

The male black grouse (black cock) has blue-black plumage, with white wing-bars, white under the tail, and curled outer tail feathers (Fig. 1); the female (greyhen) has a barred, dark brown plumage and a whitish wing-bar. Both sexes have red wattles above the eye.

**Why was this species on the Species Action List?**

It satisfied criterion 1a of the Species Action Framework as a species for conservation action (SNH, 2007). It underwent a rapid decline (over 50%) in the breeding population over the previous 25 years and as a result there was an urgent need for further targeted management. There had been relevant ecological research undertaken on the species, primarily by the GWCT and the RSPB. Both targeted and broader habitat management had made a difference to population and range recovery (e.g. the population decline in England and Wales had halted). It was identified as a UK Biodiversity Action Plan (UKBAP) Priority Species and is on the Scottish Biodiversity List. Its legal status is covered by Part 1 of the Wildlife and Countryside Act 1981, as amended.

**Habitat, distribution and abundance**

The UK population is estimated at 5,078 displaying males, two-thirds of which are found in Scotland, with the highest densities occurring in the north east (Sim et al., 2008). Black grouse are birds of transitional habitats, generally preferring the moorland/woodland edge in north Scotland and the moorland/farmland fringe in the south.
Within these areas they are largely dependent on a mosaic of scrub and an understory of heather (*Calluna vulgaris*) and blaeberry (*Vaccinium myrtillus*).

**General ecology**

In spring black grouse gather at traditional ‘lek’ sites in the morning where males display competitively and females select their mates. Males take no further breeding role. Females nest on the ground in dense vegetation and lay 6–11 eggs in late April–early June. The adult diet includes blaeberry and heather but the young depend largely on invertebrates for their first three weeks, after which they gradually shift to a herbivorous diet. After their natal movements black grouse rarely move further than 1.5 km, often attending the same lek between years.

**History of decline, contributory factors and current threats**

The UK population of black grouse has been declining in range and numbers since the 1900s. Its range declined by 28% between 1968-72 and 1988-9, while the UK population declined dramatically from an estimated 25,000 lekking males in 1990 to just 6,510 in 1995/96. The 2005 survey revealed a continuing UK decline of 22% since 1995/96. Recent losses were recorded in England but the bulk of the UK population is still declining in Scotland, where numbers between 1995/96 and 2005 fell by an estimated 29%. In particular, the south west (–49%) and south east (–69%) of Scotland suffered the largest declines (Sim *et al.*, 2008). It is believed that these declines are due to a number of factors (Cole *et al.*, 2012), including:

- Loss of important plant food sources, such as blaeberry, heather, cotton grass (*Eriophorum* spp.), rushes (*Juncus* spp.) and birch (*Betula* spp.) scrub, due to over-grazing, agricultural intensification, bog drainage or shading of the understory by conifer maturation.
- Lack of appropriate understory/open ground management (e.g. grazing, burning, swiping); this can create unsuitable rank ground conditions.
- Collisions with fences put up to exclude deer from woodlands.
- Loss of nesting cover and sources of insect food.
- Fragmentation of black grouse habitat leading to small populations that are unlikely to persist.
- Predation, mainly by foxes and crows, which may be a limiting factor in some regions.

**Aims**

**Aims for 2007-2012**

To contribute to the UKBAP objectives for black grouse, the objectives of the SAF project in Scotland were to stem the decline in numbers and range, and specifically to:

- Maintain the population of black grouse (at least to its 1996 level) and work towards the longer term aim of increasing the population.
- Restore the range of black grouse to its 1991 extent by 2011 and work towards the longer term aim of increasing the range.
- Promote recolonisation of formerly occupied areas between currently isolated populations.

**Management Action**

Conservation action was delivered through a number of different initiatives in three major areas:

- **Awareness raising and practitioner events**
  - Black grouse training, open days and awareness raising events
  - Black grouse website update
  - Black grouse conservation leaflet
- **Conservation work**
  - Fence marking and removal across Scotland
  - Black grouse management trial
  - Two black grouse recovery projects
- **Review projects**
  - A review of management prescriptions for black grouse in the UK
  - A review of black grouse conservation work in Scotland.

**Awareness raising**

A range of prescriptive techniques are available for black grouse conservation; to maximise the efficiency of management, best practice advice is needed.
Objectives: To raise awareness of black grouse conservation and advise on appropriate management techniques.

Approach: Best practice conservation advice was provided to land managers at practitioner events in the Borders, Argyll, Dumfries and Galloway, and Highland. A conservation brochure was produced and the black grouse BAP website was updated.

Partnership working and resourcing: Practitioner events were run in partnership with RSPB and GWCT. The website update and conservation brochure were produced with input from SBAP partners.

Results: Seven events were run over three years (2008–2010) delivering best practice advice to more than 100 land managers, agents and statutory agency staff. Land managers undertook black grouse management with the support of their local advisory officers. RSPB staff worked with Black Grouse BAP group partners to update the information on the Black Grouse UK website and within the conservation brochure Black grouse – habitats and land management which is available online.

Conservation work
SAF funding supported practical conservation work in four projects which included:

i) fence marking and removal;
ii) a management trial; and
iii) two specialist recovery projects.

Fence marking and removal

Background: Collisions with fences can be a significant cause of black grouse mortality. Removing fences or marking them with visible material (Fig. 2) reduces this risk.

Objectives: To reduce black grouse mortality by marking or removing high risk fences.

Location of work: Across Scotland.

Approach: SAF funding enabled RSPB Conservation staff to approach land managers with high-risk fences. Where individuals were keen, work was carried out.

Partnership working: This was a partnership project between RSPB and SNH.

Results: A total of 6,000 m of fence removal and 2,500 m of fence marking was carried out on three estates: Glen Moriston, Croik and Glentromie.

Trial management project

Background: Woodland or scrub is often important to black grouse, providing sources of food and cover, and where conditions are suitable (for example, open tree canopy and low grazing pressure) providing suitable field-layer vegetation. Black grouse distribution in Scotland appears to be closely associated with the presence of young trees or suitable woodland-edge habitat. Despite its potential importance, little is known about black grouse responses to forest management.

Objectives: To undertake positive black grouse management and identify prescriptions for use in commercial forestry design plans.

Location of work: Two Trial Management Areas (TMAs) within Galloway Forest Park (Dumfries and Galloway) and Fort Augustus (Highland).

Approach: Both TMAs were split into a series of grid squares, each 3 km² in size with a 1 km buffer. During 2007 and the winter of 2007/08 forestry practices of potential benefit to black grouse (e.g. restructuring the forestry edge, heather swiping) were undertaken within some of these blocks. To examine any associated direct (black grouse performance) or indirect (environmental change) response a number of monitoring programmes were undertaken, annually, during 2007-10, including: lek monitoring, brood counts, predator transects and vegetation surveys. Lek monitoring continued during 2011-13.

Problems and solutions: Implementing some of the forestry practices proved more challenging and expensive than originally anticipated. Consequently less forestry work was feasible.
than initially planned, which impacted on the ability to detect black grouse or environmental responses to the work within a relatively short time span. Although lek surveys continued beyond 2010, information on breeding success, predator densities and vegetation change is only available for the first four years after management. Further funding would be needed to fully assess the results over a long timeframe to realise the potential of this project and deliver the original objectives.

**Partnership working:** This was a partnership project between RSPB, SNH and FCS.

**Results:** RSPB and FCS Forest Research completed a preliminary analysis in 2010. Analysis of data collected between 2007 and 2009 failed to detect an early response from black grouse to the management undertaken. Further monitoring and analysis would be required to assess whether there is a detectable response over a longer timeframe of the forest management.

**Recovery project:**

**Black grouse groups in Scotland**

**Background:** Black grouse groups are present throughout Scotland. They provide an invaluable resource for local land managers, providing a coordinating body for black grouse monitoring and best-practice conservation advice. Although some have been running for many years, several are still in their infancy, and lack the co-ordinating capacity of larger groups.

**Objectives:** To work with local study groups and land managers to help coordinate regular lek monitoring and provide ‘best practice’ management advice for the conservation of black grouse.

**Location of work:** Grampian, Speyside, Perthshire, and the Lammermuir Hills.

**Approach:** This project ran from 2010 to 2012 and was coordinated by a senior GWCT agricultural advisor. Through practitioner events and individual visits, land managers were advised on coordinating black grouse monitoring, appropriate predator, habitat and disease management techniques and available funding packages.

**Problems and solutions:** In the Lammermuir Hills, black grouse numbers are extremely low, with conflicting land-use demands limiting recovery. Uptake of agri-environment support for black grouse across the target areas was limited. To help deliver the right management techniques in the right places, advice was targeted on a case-by-case basis through specialist farm visits.

**Partnership working and resourcing:** A wide range of land managers from the gamekeeping and farming communities were involved. Funding was provided by SNH with GWCT providing staff time.

**Results:** Eight black grouse groups in Scotland are supported by enthusiastic representatives from landholdings within group areas. Monitoring was undertaken by each group. Strenuous efforts were made to hold two meetings a year within each group area, though this was not always achieved because of the annual work load in the upland estate calendar. In the Lammermuir Hills there was an increase in SRDP applications during the project. The agricultural advisor facilitated eight submissions, all of which were successful.

**Recovery project:**

**Argyll and Stirling recovery project**

**Background:** In response to the decline in the south and west of the Scottish range a three year recovery project took place in Argyll and Stirling.

**Objectives:** To provide a better understanding of black grouse within Argyll and Stirling, and improve numbers and range through increasing the amount of suitable habitat.

**Approach:** A black grouse Project Officer coordinated this project, and made annual lek counts with about 35 volunteers. Landowners, tenants and agents surrounding core lek sites (with at least three birds) were contacted, and advice provided on an individual basis and through two advisory workshops. SRDP provided the main funding mechanism for the habitat management. This project ran from 2009 to 2011.

**Problems and solutions:** Landscape-scale management presents both a financial and practical challenge, as core populations within Argyll are widely dispersed. Some landowners who attended the workshops sought further advice but only a few incorporated all the recommendations of the Project Officer into final applications. Low payment rates for some SRDP options reduced the number of options that landowners applied for. Thus, management was largely delivered opportunistically.
Partnership working and resourcing: A wide range of land managers from the gamekeeping, farming and forestry communities were involved with the project. This project was a partnership between RSPB, SNH, FCS, Scottish Power, and GDF Suez.

Results: During 2011 a total of 241 displaying males were recorded, with an increase from 90 to 99 males across 19 comparable leks (2009–11). Thirty people attended advisory workshops, eight farmers subsequently requested site visits and four secured SRDP funding for black grouse habitat management. The Project Officer undertook 36 sites visits, input into 19 Long Term Forest Plans and 33 moorland applications (17 of which were successful).

Review projects

To assist future conservation delivery SAF supported two review projects: ‘a review of management prescriptions for black grouse in the UK’, herein referred to as the ‘Calladine review’, and the ‘black grouse Conservation Review Project’ (CRP).

Calladine review

Background: There are a number of monitoring techniques, delivery mechanisms and management prescriptions currently advocated for black grouse conservation. The 2002 Calladine review evaluated these techniques, and the SAF project funded an update.

Objectives: To evaluate the efficiency of black grouse monitoring techniques, delivery mechanisms and management prescriptions currently advocated by conservation staff.

Approach: The review collated details of the advice given to land owners and managers. Summarised into prescriptions or themes these were reviewed by reference to relevant literature and scored against observed or expected effectiveness

Partnership working and resourcing: This was a partnership project between RSPB and SNH, with input from GWCT and FCS.

Results: The review (Cole et al., 2012) can be downloaded from the RSPB website.

Conservation Review Project

Background: Over the past decade significant effort has been invested in black grouse monitoring and conservation management. However, the breadth and efficacy of this work, on a national level, is largely unknown.

Objectives: To examine the extent and efficiency of recent black grouse monitoring, Scotland Rural Development Programme (SRDP) expenditure, and conservation effort, across Scotland, through three standalone reports.

Approach:

- The first report identified the location of all black grouse monitoring undertaken across Scotland between 2001 and 2011. It assessed the extent and results of monitoring and compared them with the 1991 Breeding Bird Atlas range and the most recent national population survey (i.e. Sim et al., 2008).

- The second report quantified SRDP expenditure of relevance to black grouse and assessed its targeting.

- The third report identified the location and extent of black grouse conservation work between 2007 and 2011.

Partnership working and resourcing: This was a partnership project between RSPB, SNH, GWCT and FCS.

Results:

- Within Scotland an estimated 50% of the 1991 Breeding Bird Atlas range was monitored between 2001-11 (Fig. 3) with an aggregated number of 4,713 males recorded by the most recent surveys (41% higher than the last national estimate) (Hawkes and Corrigan, 2013).

- Under SRDP, over £8 million was drawn down through the black grouse package and a further £92 million was committed through Rural Priority options with potential black grouse benefit (Hawkes, 2013a; Fig. 4).

- In Scotland, black grouse conservation has been delivered through five specialist recovery projects between 2007–12, alongside management on at least 12 nature reserves and 22 forests on the national estate (Hawkes, 2013b; Fig. 5). The reports can be downloaded from the RSPB website.
Fig 4. SRDP black grouse package spend (from Hawkes, 2013a).
Fig 5. Black grouse recovery projects 2007-13.
Lessons Learnt, Further Work and Future Recommendations

Black grouse monitoring

Over the past ten years significant resources have gone into black grouse lek monitoring. Survey extent across Scotland is good, but currently there is no national coordination of localised monitoring data. Several data holders have reservations about information sharing whilst others lack the staffing capacity to collate records. Consequently, there is no mechanism for assessing the status and distribution of the population between national surveys.

Recommendations

• Gain a better understanding of status and distribution of the Scottish black grouse population by coordinating survey findings through a national monitoring scheme.

Agri-environment

Although the overall effectiveness of SRDP is unknown, black grouse package expenditure was delivered well in some areas and poorly in others. Future resource needs to be targeted towards those areas of greatest conservation concern.

Recommendations

• Examine whether SRDP and previous grant schemes have assisted black grouse recovery.
• The black grouse SBAP group recommends that future agri-environment resource should be targeted towards the south of the central Scotland belt, the region of greatest conservation concern.

Conservation delivery and management prescriptions

Recovery projects are an important mechanism for delivering targeted conservation action across a landscape scale. Future delivery would be enhanced by focussing on prescriptions with a known population level effect, and targeting areas of conservation concern.

Recommendations

• Continue to support projects encouraging population recovery and range expansion. These should primarily target the vulnerable south Scotland population with additional reactive advice support elsewhere.
• Advocate moorland management, new native woodland creation and predator control as key prescriptions for black grouse management.
• Recommend best practice guidance to the Scottish Government to ensure agri-environment support is fit for purpose and available in the right areas.
• Conduct further research to evaluate the effectiveness of potentially important management techniques.

Long term delivery

To secure the future of this vulnerable bird, we need to make black grouse less conservation dependent.

Recommendations

• The SBAP group should lead on the production of a strategic approach to black grouse conservation delivery in Scotland.

New and ongoing work since SAF ended

• Similar management for black grouse continues, supported by funding via the Scottish Rural Development Programme.
• In south and west Scotland a black grouse project officer was employed by the RSPB from March 2013 to May 2014. The project officer coordinated and conducted lek surveys in Argyll, Central Scotland and Ayrshire and provided advisory support to land managers.
• The collation of black grouse lek survey results from across Scotland was trialled in 2014.
• A desk study looking into how the scale and quality of moorland habitats influences black grouse numbers and distribution in southern Scotland was published (Warren et al., 2014). It is hoped that this will contribute to the evidence base for the development of a strategic conservation plan.
Key Management Messages

- Black grouse should be managed at a landscape scale.
- A better understanding of status and distribution of the Scottish black grouse population should be gained by coordinating survey findings through a national monitoring scheme.
- Support should continue for projects encouraging population recovery and range expansion. These should primarily target the vulnerable south Scotland population with additional reactive advice support elsewhere.
- Moorland management, new native woodland creation and predator control should be advocated as key prescriptions for black grouse management.
- Further research should be conducted to evaluate the effectiveness of potentially important management techniques.

Further Information


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References


The SAF Partners

- Scottish Natural Heritage
- Royal Society for the Protection of Birds
- Forestry Commission Scotland
- Game and Wildlife Conservation Trust
- GDF Suez
- ScottishPower Renewables

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Eurasian Beaver

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Summary

- The feasibility and desirability of reintroducing beaver to Scotland has been explored over many decades, and progressed in detail since the mid-1990s.
- The inclusion of beaver in the Species Action Framework (SAF) demonstrated the continued interest in beaver reintroduction issues, and prompted a licence application to release beavers at Knapdale, Argyll, for the purpose of running a scientifically monitored trial. The licence was approved (2008) and the first animals were released in May 2009 as part of the ‘Scottish Beaver Trial’ (SBT).
- The SBT was a complex project, which required careful planning and management, involving issues ranging from the identification of necessary resources, capture and quarantine requirements, animal tracking and veterinary requirements, independent scientific monitoring, local consultation and engagement, visitor management and associated education programmes, and potential impacts on designated site interests.
- Other initiatives and projects concerned with beavers ran over the same period. These included the work of the Tayside Beaver Study Group (TBSG), the Beaver-Salmonid Working Group (BSWG), the National Species Reintroduction Forum, and a number of stand-alone projects.
- The results of all of this work were collated as a package of information and sent, together with the Beavers in Scotland report produced by Scottish Natural Heritage (SNH), to the Scottish Government in June 2015 to support their decision making.
- On 24 November 2016 Roseanna Cunningham MSP, Cabinet Secretary for Environment, Climate Change and Land Reform, announced that beavers will remain in Scotland.

Introduction

On 24 November 2016, it was announced by Scottish Government that beavers will remain in Scotland. This represents the first, formal reintroduction of a mammal species anywhere in Britain.

Species background

The Eurasian beaver (Castor fiber) is a large, semi-aquatic rodent that is believed to have died out in Britain about three centuries ago. It is listed on Annex IV (and Annex II) of the EC Habitats Directive.
Directive, and therefore there is a requirement for European Union Member States to study the desirability of reintroducing such species where they have become extinct. The beaver is a species that many claim can have a significant influence on ecosystem function and health. It is a charismatic species that could serve to raise wider biodiversity issues such as riparian woodland management, aspen restoration, wetland biodiversity and dead wood habitat creation. It was therefore included on the SAF list as a species worthy of further conservation action, in particular through a trial reintroduction.

**Habitat, distribution and abundance**

The Eurasian beaver inhabits riparian broadleaved woodland or scrub bordering fresh standing waters or slow-moving watercourses. It occurs from western Europe eastwards to the Chinese-Mongolian border region. By the beginning of the twentieth century there were thought to be only around 1,200 animals surviving in eight populations (Halley and Rosell, 2003). Three discrete western European populations survived in southern Norway, on the Elbe in Germany, and the Rhone in France. In the east, small populations persisted in Belarus, Russia, Ukraine, Mongolia and China. The twentieth century marked a dramatic turnaround. As a result of changes in wildlife legislation, management practices and enhancements, translocations/reintroductions and natural recolonisation, the total population is now estimated to be a minimum of one million animals (Halley *et al.*, 2012) although this is heavily weighted towards eastern and northern Europe. This represents one of the most strikingly successful conservation feats for a European vertebrate.

**General ecology**

The beaver is herbivorous, and feeds on herbaceous and woody, broadleaved species (Figs. 1 and 2). It favours burrows in banks as ‘nesting’ places, but may build lodges of piled logs where it is unable to burrow (Fig. 3). The beaver will sometimes dam streams to maintain water levels and construct canals that allow it to travel further away from the main body of water (Figs. 4 and 5). It is monogamous and lives in family groups. The Eurasian beaver has been described as a ‘keystone’ species and it is argued that its restoration would be beneficial to a wide range of species and habitats.
### Aims

#### Aims for 2007-2012

At the beginning of SAF the key, over-arching aim was:

- To support at least one reintroduced Eurasian beaver population in the wild in Scotland.

A wide range of aims and objectives were later identified for the various beaver initiatives that were run (e.g. see the aims of the Scottish Beaver Trial in the following section), but these all related to the overall need to collate necessary information by 2015 to support a decision on the future of beaver reintroduction.

### Management Action

#### Background

SNH started investigating the feasibility and desirability of reintroducing beaver to Scotland in 1995, prompted to some extent by the inclusion of Eurasian beaver on Annex IV of the EC Habitats Directive. During the 1990s a number of projects were set up to look at the issues surrounding beaver reintroduction (see below) and these were used to help inform a national consultation held in 1998. This led to a decision to run a trial reintroduction to allow some of the issues raised during the consultation to be looked at in more detail. The whole process took account of the IUCN Reintroduction Guidelines (IUCN, 1998).

The next decade was dominated by efforts to obtain approval for, and organise, a trial reintroduction. Knapdale Forest in Argyll was identified as a possible site for a trial as early as 2000, and in the same year a local consultation was organised. SNH applied for a licence in 2005 to release beavers at Knapdale but the Scottish Government turned this down. Two years later the beaver was included on the SAF list as a species to be prioritised for conservation action (SNH, 2007), thereby setting beaver within a wider, national context of strategic, targeted management. Two Scottish NGOs, the Scottish Wildlife Trust (SWT) and Royal Zoological Society of Scotland (RZSS), then made a second licence application which was approved in 2008. As a result the SBT was established, and the first ever licensed release of a mammal species into the wild in Britain took place in May 2009 when three families of beavers were released at Knapdale.

After the launches of SAF and the SBT, new challenges and opportunities arose, and new beaver initiatives were developed. These are listed below. The outputs of all of these formed a package of information that SNH collated and submitted to Scottish Government, together with the *Beavers in Scotland* report (Gaywood, 2015), in June 2015. They were designed to support Ministers in making a decision on the future management of beavers, and beaver reintroduction, in Scotland.

### The main projects and initiatives

#### The Scottish Beaver Trial

The SBT was the central beaver-related project that developed out of the SAF process. Five years of post-release monitoring by a consortium of independent scientists ended in May 2014 after which there was a year of final data analysis and report writing that was incorporated in the *Beavers in Scotland* report in 2015.

#### The Tayside Beaver Study Group

A population of beavers has developed on Tayside. This arose through unauthorised escapes from private collections, and possible deliberate releases. Initial attempts to capture and re-house the beavers stopped when it became apparent the numbers were far higher than originally estimated. The Scottish Government decided to ‘tolerate’ the presence of the beavers until the Ministerial decision, and the ‘Tayside Beaver Study Group’ (TBSG) was set up in 2012 to help collate more information on the population and their impact. A part-time project officer supported the work of the group.

#### The Beaver-Salmonid Working Group

Concerns regarding the potential impact of beaver dams on migratory salmon and trout were raised by fishery organisations and this led to the formation of the Beaver-Salmonid Working Group (BSWG) in 2009. This group was given the aim of examining the issues surrounding the interactions between beavers and salmonid fish. Its membership included representatives from government and non-government, science and fishery sectors. A part-time project officer supported the work of the group.
The National Species Reintroduction Forum

The National Species Reintroduction Forum (NSRF) was set up in 2009, is chaired and supported by SNH, and is made up of a wide range of land use and conservation bodies from both the public and NGO sectors. It has an advisory role, and its remit covers all types of conservation translocation, and deals with broad scale, strategic issues, most recently with the development of the ‘Scottish Code for Conservation Translocations’ (National Species Reintroduction Forum, 2014). It has been involved with a number of initiatives that relate to beaver reintroduction.

Other beaver projects and initiatives

There were several other projects that were due to be completed before the report to the Minister in 2015. These included developing methods to examine beaver genetics, reviewing beaver management, and refining a beaver population modelling tool. This is in addition to research and review projects which were completed before the release of beavers in Scotland, and the work being undertaken in England (Gurnell et al., 2009), Wales, the rest of Eurasia and North America.

The pre-release work – key issues and the work done

Historical evidence and cause of extinction

Early questions were: Can we confirm the beaver once lived in Scotland, why did it die out, and was the cause of dying out still a problem for any reintroduction?

Initial work (Conroy and Kitchener, 1996; Kitchener and Conroy, 1996) found that the Eurasian beaver appeared to have been widespread throughout Britain, including Scotland. Some palaeontological and archaeological remains, together with written historical information, suggest that it was present here until the early 16th century – the last Scottish record is mentioned in the 1526 ‘Cronikils of Scotland’ and refers to beavers as being abundant in the Loch Ness area. More recently Coles (2006) has found evidence that beavers may have been present well into the late 18th century in England. The cause of this loss to Scotland, as elsewhere across Europe, is believed to have been unsustainable levels of hunting for the valuable beaver pelts, and to a lesser extent for castoreum and meat. These causes are unlikely to be a problem for any new reintroduction. Habitat loss is thought to have been a relatively minor and localised factor.

Provenance

What would be the most appropriate source of beavers for any Scottish reintroduction?

Morphological studies of British fossil beaver material led Kitchener and Lynch (2000) to recommend Norway as the most suitable donor source. This recommendation was applied to the Scottish Beaver Trial for which only Norwegian animals were used. This was felt to be a defensible, precautionary approach until more information could be gathered on beaver genetics and donor source suitability. However, animals of mixed provenance now live in Tayside where there have been unplanned releases.

Genetic work undertaken several years later suggested that there may be a western ‘form’ (variously described as an ‘evolutionary significant unit’ or ‘haplogroup’) of beaver which originates from the remaining Norwegian, French and German relict populations, and an eastern form which originates from another five relict populations, suggesting at least two refugia existed during the last ice age for the species (Ducroz et al., 2005; Durka et al., 2005). Many beavers across Europe are now of mixed stock due to extensive translocations over past decades. However, a recent study by Senn et al. (2014) has demonstrated, through additional sampling and nuclear genetic analysis, that this eastern-western division is not as obvious as previously thought. These studies, and associated provenance issues and implications, are further examined in the SNH Beavers in Scotland report (Gaywood, 2015).

There is a North American species of beaver (Castor canadensis) that cannot easily be distinguished from the Eurasian species in the field. There is broad agreement across the conservation sector that this non-native species should not be released in Britain. The North American species has been introduced into parts of northern Europe and is now well established in Finland. It has only recently become clear that the species appears to be present in some numbers in the Germany-Belgium-Luxembourg border area (Schley et al., 2009). The two species are not known to hybridise in the wild, although there are suggestions that the North American species out-competes the Eurasian species, at least in more northern latitudes. It seems unlikely that the North American species
has been released in Scotland, intentionally or unintentionally, and it has not been detected during the genetic screening on Tayside to date.

Public and animal health factors also need to be considered when sourcing beavers. Beavers imported from Europe to the UK have usually had to undergo a six months rabies quarantine, although more recently Scottish Government has agreed that beavers from Norway (which is rabies-free) only need to undergo a limited period of health surveillance (one month in Norway), subject to certain veterinary conditions. This has significant animal welfare and cost benefits, and potential knock-on effects in terms of increasing the success of any reintroduction.

The presence of a range of other pathogens should be checked during quarantine, although it became clear that animals were not being effectively screened for the taenid tapeworm *Echinococcus multilocularis*, and consequently importers were often unaware whether their beavers were infected or not. This tapeworm is a public health concern because it can cause human alveolar echinococcosis, a hepatic disorder that resembles liver cancer and is highly aggressive and potentially lethal. Britain and Norway are currently free of the tapeworm, but it does occur in other parts of Europe (such as Germany) from which beavers have been sourced for collections around Britain, including Tayside. Although some of the Tayside animals escaped into the wild, the probability that this resulted in the establishment of the tapeworm in native wildlife is thought to be low, although there is a level of uncertainty (Defra, 2012). Any future proposals to release beavers would need to demonstrate there was no risk of infection, for example by ensuring the animals come from tapeworm-free countries or captive-bred sources.

Identifying potential beaver habitat at the national scale

Can we be confident that there is sufficient and suitable habitat in Scotland that would allow a self-sustaining, viable beaver population to establish itself in Scotland after any reintroduction?

Modelling and GIS tools have been used to identify potential beaver habitat across Scotland, and to predict possible population levels following any release. A first map of potential beaver habitat was published by Webb *et al.* (1997), although this was revised by SNH using updated GIS datasets (Gaywood *et al.*, 2008), and was revised again using new datasets and criteria based on the latest ecological research (Stringer *et al.*, 2015). These illustrate that there are some extensive networks of freshwater and riparian broadleaved woodland habitat across many parts of the country. Preliminary estimates of potential population size were 178-386 family groups within 45 distinct patches across the country (South *et al.*, 1999; Rushton *et al.*, 2001), although these figures are probably an underestimate.

Examining the potential effects of beaver presence - Pre-release work

What effect might beavers have on the environment in Scotland?

A number of reviews were commissioned before permission was sought to undertake a trial reintroduction. These involved literature reviews, and collation of information provided by specialists on the European and, to a lesser extent, North American experience with beavers. They included:

- Development of beaver habitat survey protocols (Macdonald *et al.*, 1997).
- Review of beaver dam-building and hydrology (Gurnell, 1997).
- Review of beavers and fish/fisheries (Collen, 1997).
- Review of beavers and woodland habitats (Reynolds, 2000).

These identified some of the potential risks and benefits of beaver presence in Scotland. A very thorough assessment of the risks and benefits on natural and human environments is presented in the *Beavers in Scotland* report (Gaywood, 2015).

Assessing public desirability – consultations

Do people want the beaver back in Scotland? This question was posed during a national consultation during which the provisional evidence that SNH had collated was presented (Scott Porter Research & Marketing Ltd., 1998). The results of the consultation showed a majority of the public supporting the idea of beaver reintroduction, although strong reservations were expressed by some organisations within sectors such as agriculture and field-sports. This led to a decision to run a trial reintroduction to allow some of the concerns, and potential benefits, to be looked at in more detail. There have also been a few other surveys which involved an examination of public
perceptions on beaver reintroduction, and which have tended to give results in support of releases (Gaywood et al., 2008).

The post-release work – The SBT

The trial approach set out in the SBT was developed in response to the national consultation and SAF. It has been a complex programme of work that has been reported on in detail in a wide range of final outputs, but some key components are summarised here.

Aim of the trial

The aims of the SBT were set out in the original licence application. They were to undertake a scientifically monitored trial reintroduction of the Eurasian beaver to Knapdale, mid-Argyll, for a five year period in order to:

• Study the ecology and biology of the Eurasian beaver in the Scottish environment.
• Assess the effects of beaver activities on the natural and socio-economic environment.
• Generate information during the proposed trial release that will inform a potential further release of beavers at other sites with different habitat characteristics.
• Determine the extent and impact of any increased tourism generated through the presence of beaver.
• Explore the environmental education opportunities that may arise from the trial itself and the scope for a wider programme should the trial be successful.

The licence application also sets out a range of success and failure criteria to help measure the SBT

Identification of a release site

The agreement and cooperation of sympathetic land owners was needed for the trial site. Early in the process Forestry Commission Scotland (FCS) offered their support, and so a first stage was to overlay the FCS land holding with the SNH map of potential beaver habitat (Webb et al., 1997). Shortlisted sites were then field-validated using the protocol of Macdonald et al. (1997), and practical issues discussed with relevant personnel. It was never going to be possible to find a perfect site, but Knapdale (Fig. 6) was put forward based on its ecological suitability, its uncomplicated land ownership (FCS was the sole owner), practical benefits (e.g. proximity to SNH and FCS offices, visitor facilities and extensive forest track network) and its relatively contained network of catchments, therefore reducing the risk of extensive beaver dispersal outside the trial area. A model to predict the possible outcomes of any release at Knapdale was produced (Rushton et al., 2002). Knapdale is also designated as a Special Area of Conservation, Special Protection Area and Site of Special Scientific Interest, and therefore, because it was decided the project would have a ‘significant effect’ on the relevant Natura natural heritage features, an ‘appropriate assessment’ had to be done.

Local consultation

SNH had run a local consultation in 2000, but SWT/RZSS updated this with a further consultation in late 2007. This involved local meetings and open days, the distribution of leaflets and an invitation to individuals and organisations to submit views, and highlight any potential issues. The results showed strong support across mid-Argyll as a whole, although a small majority against the trial amongst those living near to Knapdale. A further public consultation carried out by the SWT/RZSS in early 2014 showed a majority support for beaver reintroduction (Jones and Campbell-Palmer, 2014.).

Licence application process

Section 14 of the Wildlife and Countryside Act 1981 makes it an offence to release into the wild any animal that is of a kind ‘not ordinarily resident’ in Great Britain. The SWT and RZSS therefore required a licence from Scottish Government to allow release. The application set out full project
details, including overall aims, success and failure criteria and exit strategy options. The subsequent licence issued by the Scottish Government contained 32 conditions relating to subjects such as how the project would be monitored and managed, including in relation to the designated site features. Now that The Wildlife and Natural Environment (Scotland) Act 2011 applies in Scotland, SNH will be the licensing authority for any future proposals of this type. Licences will be required before any further beaver releases in Scotland are permitted.

**Timescale**

The overall project was seven years, with one year preparation, five years post-release monitoring, and a seventh year of analysis with reporting to be completed by May 2015. This timeframe had to be a compromise between ensuring sufficient time was allowed for useful information to be derived from the project, but short enough that there was a good chance of sufficient resources being made available.

**Project management and organisation roles**

The SWT and RZSS were the licence holders and project managers. FCS was the landowner and ‘host partner’. A ‘Project Team’ and a number of working groups were set up by the partners to coordinate project management and ensure delivery of work on the ground. FCS led on ensuring health and safety issues were properly addressed during the trial period. One licence condition set by the Scottish Government was that SNH should coordinate the independent monitoring programme in collaboration with other parties, and ensure the licence conditions were being addressed, and a ‘Research and Monitoring Coordination Group’ was therefore established to coordinate the independent monitoring programme. Also, and importantly, an independently chaired ‘Local Stakeholders’ Forum’ was organised to help set up good lines of communication between members of the local community and those managing the SBT.

**Resources**

It was necessary from an early stage to ensure sufficient funding was in place to cover the whole project period. The SWT and RZSS were responsible for sourcing the approx. £2 m required for the entire project. A number of contributions were secured, not least £1m from Biffa Award. SNH contributed approximately £250 K specifically to the monitoring work, with significant additional resources contributed by the independent monitoring partners.

**Capture, holding, transport, quarantine/screening**

This complex process started with identifying personnel in Norway prepared to assist with the capture and holding work. Full details of the methods used are given in the ‘Captive Management Guidelines’ for beavers (Campbell-Palmer and Rosell, 2013). The Norwegian specialists identified wild beaver families suitable for capture. Initially a decision was made to catch and release whole families to try and reduce the risk of post-release dispersal, although this approach also created some problems (e.g. increased capture time and cost, and quarantine mortality), with the result that subsequent releases used young single animals paired in captivity prior to release. Captured animals were held in purpose-built holding facilities, and checked by vets. Relevant export and import permits had to be arranged, and transport crates sourced. The first and main group of animals had to undergo a six-month rabies quarantine at a facility based in Devon. Six animals died during this initial quarantine (Goodman, 2014). Subsequent imports went direct to RZSS holding facilities in Edinburgh and Kincraig, and did not have to undergo the six-month rabies quarantine, although other health checks had to be made (see above).

**Release**

Release points with suitable quality habitat were identified around Knapdale, sufficiently spaced to reduce the risk of territorial disputes between neighbouring animals during the sensitive period immediately after release. Soft release methods were used in the early stage of the project. Artificial lodges were built from straw bales, bedding was marked with the animals’ scent, and the animals were placed inside and blocked in temporarily. In the event, these artificial lodges were not used to any great extent. Temporary lines of open fencing (designed to allow the movement of otters) were placed along two key water bodies at one release site which might have been used as dispersal routes out of the trial area. Sixteen animals were released at four loch sites during the first sixteen months of the trial (Fig. 7) – this relatively small number was designed to address the aims of the time-limited trial, and is probably insufficient for any long-term ‘founder’ population
for Knapdale. Further details on the release process are given in Campbell-Palmer and Rosell (2013) and Jones and Campbell-Palmer (2014).

**Fig 7. A beaver at Knapdale.** © Lorne Gill/SNH

**Management of animals**

This element was led by SWT and RZSS, in consultation with FCS and SNH. SBT field staff were based locally throughout the whole trial period, an office and equipment store were established near the site, and dedicated vehicles provided. An un-fenced trial site boundary was agreed. Protocols were established on how to deal with animals that moved out with the boundary or which were not observed within the trial site after fixed periods of time. Attempts were made to trap and return any animals detected outwith the trial site. The movement of animals was monitored for management purposes through a combination of radio telemetry/GPS tracking, direct observations, field sign surveys, camera traps and trapping/release (details on some of these methods are provided in Campbell-Palmer and Rosell, 2013; Jones and Campbell-Palmer, 2014). Some of this information was also used for the scientific monitoring work, and the methods are described in Campbell et al. (2010) and Harrington et al. (2011, 2012, 2013, 2015). Animal health and welfare issues were managed by RZSS veterinary staff with support by local vets, with additional independent monitoring by the Royal (Dick) School of Veterinary Studies of Edinburgh University. Floating mink raft traps were set up at a number of sites around Knapdale, and records made of the small number of mink that have been detected, trapped and dispatched.

**Scientific monitoring of the trial**

A Monitoring Programme was developed by SNH in collaboration with its independent monitoring partners. To ensure the process was independent, SWT and RZSS did not contribute to the scientific design, interpretation and reporting, but were involved in discussions relating to the practical application of work on the ground, and undertook some of the data collection. SNH worked in direct partnership with a range of organisations leading on various natural heritage issues:

- Beaver ecology – with the University of Oxford.
- Riparian mammals – with the University of Oxford.
- Fish ecology – with the Argyll Fisheries Trust.
- Dragonflies and damselflies – with the British Dragonfly Society.
- Woodland habitat – with The James Hutton Institute.
- Loch ecology/aquatic plants with the University of Stirling.
- River habitat – with the University of Stirling.
- Hydrology – with the University of Stirling.
- Socio-economics – with Scotland’s Rural College.

Other independent organisations led on issues outwith SNH’s specialist remit (historic sites, public health, animal health and water chemistry):

- Beaver health – Led by the Royal (Dick) School of Veterinary Studies.
- Water chemistry – Led by the Scottish Environment Protection Agency.
- Public health – Led by Argyll and Bute Council.
- Scheduled monuments – Led by Historic Scotland.

The final reports for these monitoring projects can be found on the [SNH website](#), and the results are summarised in the SNH *Beavers in Scotland* report (Gaywood, 2015).

**Additional opportunities**

The SWT and RZSS developed an education programme focussed around the SBT, and set up an education officer post to engage with the public, educational institutions and special interest groups. Visitor interpretation opportunities and facilities were also developed in close collaboration with
The post-release work — The information that was collected

The projects described above helped to produce a range of information, briefly summarised below. Full results from these studies are published on the SNH website. All of this, together with information gathered from other European and North American sources, helped to inform the decisions on the future of beavers in Scotland.

Beaver ecology and genetics

The monitoring of the beavers at the SBT was led by the University of Oxford in collaboration with SNH. Data were collated by SBT field staff using methods established by the University of Oxford/ SNH. A combination of direct observations, field sign surveys, trapping, radio telemetry and GPS was used to study the population dynamics and habitat utilisation. Some of this information was also used by the SBT for project management purposes, for example establishing whether beavers were still within the study site or had moved away. The methodological design and results are available (Harrington et al., 2015).

On Tayside, a survey was undertaken in 2012 to assess the distribution and establish the size of the beaver population within the catchment (Campbell et al., 2012). It was estimated about 38-39 family groups were present, with each family using a mean waterway length of 2.9 km ± 1.5 SD. Lodge productivity surveys were also carried out during the summers of 2013 and 2014 to see how many kits are born to a sample of the family groups (Campbell-Palmer et al., 2015). All of this TBSG and SBT data was used to test and refine the existing beaver population model referred to in the description of the pre-release work above (Shirley et al., 2015).

A sample of the Tayside animals were also trapped, and any dead animals found were examined, to assess their genetic status. All animals caught were confirmed as Eurasian beaver, and issues relating to their ‘genetic health’ assessed (McEwing et al., 2015).

Animal and public health

Animal health and welfare within the SBT was managed by the RZSS, with independent monitoring by the Royal (Dick) School of Veterinary Studies. The programme design is described in Goodman et al. (2012) and Goodman (2015). Post-release monitoring was done through visual observations, and annual trapping and examination during which blood, faecal and other samples are taken.

Public health issues have also been raised in relation to beavers, in particular giardiasis although a study undertaken several years ago found little evidence that this has been a concern in parts of Europe where beavers occur (Galbraith and Gaywood, 2002). A programme of public health monitoring was set up within the SBT, led by Argyll and Bute Council. This involved the
collection of water samples from key points around the trial area, and analysis for protozoan parasites such as *Giardia* and *Cryptosporidium*. The results from the pre-release, baseline monitoring are given in Morrison (2004), and the final SBT results are provided in Mackie (2014). A further and wider examination of public health risk associated with beavers in Scotland was organised by the Centre of Expertise on Animal Disease Outbreaks (EPIC, 2015).

A beaver screening programme was also undertaken on Tayside, led by the RZSS. Since the precise origin of the Tayside beavers could not be confirmed, a particular focus of the work was assessing whether the tapeworm *Echinococcus multilocularis* was present. No signs of disease were found (Campbell-Palmer et al., 2015). The Scottish Government also increased the screening of the fox population, since fox is a primary host of the parasite. The fox screening also produced negative results.

**Aquatic and semi-aquatic biology**

The University of Stirling, in collaboration with SNH, led on the monitoring of loch ecology at the SBT, with a particular focus on the macrophyte communities and the indirect effects of dam creation and water level changes, and the direct effects of herbivory (Figs. 10 and 11). This is a topic that has been poorly studied elsewhere, probably in part due to the technical difficulties of working in aquatic environments. The methods and interim results are presented in Willby et al. (2010, 2011), with the final results in Willby et al. (2014). Some additional loch habitat characteristics, such as invertebrate communities and bathymetry were also assessed at one particular loch that had been particularly affected by the construction of a beaver dam. Beaver interactions with loch ecology were also the subject of a University of Stirling PhD which was completed in 2014, and which involved fieldwork at the SBT and at a site on Tayside. Some initial work has been published on beaver foraging behaviour in relation to water lilies (Law et al., 2013), and builds on the methods and results of an earlier PhD undertaken at the same university and using the same Tayside field site (Jones, 2006).
water chemistry samples were collected by SBT field staff and analysed by the Scottish Environment Protection Agency (SEPA).

Fig 12. Hydrology monitoring at Knapdale. Automatic loggers and stage boards were used. © Martin Gaywood/SNH

**Woodland**

A woodland monitoring programme was established at Knapdale by the James Hutton Institute, in collaboration with SNH (Moore *et al.*, 2010, 2011, 2013; Iason *et al.*, 2014.), partly informed by an initial assessment of potential methods (Armstrong *et al.*, 2004). This established 17 transects, comprising 65 (4 x 10 m) permanent vegetation plots between zero and 30 m from the water’s edge. Data were collated on factors such as tree species and size selection, felling intensity in relation to distances from lodges and water’s edge, and regrowth from felled stumps (Fig. 13).

Fig 13. Woodland monitoring at Knapdale has included the use of tags to identify individual tree stems. © Lorne Gill/SNH

The woodland at Knapdale is a qualifying feature for the SAC, and the lichen assemblages associated with a number of hazel stands around the site are an important component. There was very limited beaver activity within these hazel stands in the early years of the SBT, but more recently there has been an increase in the number of hazel stools felled, or partly felled. These stands were therefore carefully monitored by SNH, to inform any decisions that may be needed on their future management.

**Species and biodiversity**

Within the monitoring programme, the emphasis was on looking at the effects of beavers on habitats at the site, and this was used, together with information from other sources, to judge how habitat changes may affect specific species or groups of species. It was not possible, with the limited resources available, to monitor beaver effects on many individual species, or different groups of species. There were some exceptions however. Otter is a qualifying interest for the SAC at Knapdale, and has also been highlighted as a species valued by local people. Annual otter sign surveys were therefore undertaken by SNH. Any mink signs were also recorded at the same time (water vole is not believed to be present at Knapdale). Dragonflies and damselflies (Odonata) are a notified feature for the SSSI at Knapdale, and therefore the British Dragonfly Society monitored two species of particular interest, the hairy dragonfly (*Brachytron pratense*) and beautiful demoiselle (*Calopteryx virgo*).

Information from the standard ‘Site Condition Monitoring’ for the designated site features at Knapdale, which includes black-throated diver, marsh fritillary butterfly, the bryophyte assemblage and woodland breeding bird assemblage, were also made available for the final reporting on the SBT.

Fish species were also monitored at the SBT by the Argyll Fisheries Trust in collaboration with SNH. This was done by electrofishing and redd count surveys on a number of the small streams both within and outwith the SBT site (Argyll Fisheries Trust, 2015), some of which contain trout populations.
The potential effects of beaver on fish and fisheries has been a particularly controversial topic during the beaver reintroduction debate, in particular the specific issue of beaver dam presence and potential impacts on the movement of Atlantic salmon and sea trout. The SBT does not have any salmon populations within its study area, and therefore other means of examining the issue were initiated.

Recent work on this topic started with the most comprehensive review of the beaver-fish issue undertaken to date anywhere (Kemp et al., 2010, 2012), and involved a meta-analysis of the literature and expert opinion. This found that most research is biased towards North America (88%), with benefits to fish cited more frequently than costs (184 times to 119 times). Positive findings were more frequently based on quantitative evidence (51%), while discussion of negative effects was often speculative (71%). During the survey of expert opinion, perceived positive effects were recorded as increased fish abundance and productivity, and perceived negative effects as impediments to movement due to damming, and impacts on available spawning habitat.

More recently the BSWG examined the beaver-salmonid issues in the Scottish context. This included some preliminary field examinations of fish movements in relation to a series of dams on one of the Tay tributaries (Fig. 14), a mapping study to assess to what extent potential beaver habitat may overlap with salmon habitat within a number of catchments, and the collation of further information on beaver and fish/fisheries ecology and management issues. This was incorporated in to a final report (BSWG, 2015). The discussions also led to the creation of a new PhD studentship based at the University of Southampton from 2014, which is looking at fish movement and behaviour in relation to beaver dams.

SNH also undertook its own detailed meta-analysis of published studies on the role of beavers as ‘ecosystem engineers’, and their possible impact on the biodiversity of Scotland (Stringer and Gaywood, 2016). This showed that, overall, beavers have a very positive influence on biodiversity, and a widespread positive effect is predicted in Scotland. There are some specific habitats and species of conservation importance, such as the Atlantic hazelwood climax community and aspen woodland, where there may be detrimental impacts and therefore where targeted management would be required.

Socio-economics
Scotland’s Rural College (SRUC), in collaboration with SNH, led on the monitoring of the socio-economic factors relating to the SBT (Moran and Lewis, 2014). Work was also done on examining the socio-economic implications of beaver presence on Tayside (Hamilton and Moran, 2015). These socio-economic studies involved measures from business surveys, visitor and guided walk counts, volunteering and education programmes, damage cost estimates and non-market valuation.

Scheduled monuments
At the south end of Loch Coille-Bharr, one of the beaver release lochs at the SBT, there are the remains of the underwater foundations of a crannog. Historic Scotland (now known as Historic Environment Scotland) therefore monitored any possible effects of beaver presence on this scheduled monument (Cavers, 2009; Brann, 2014).

Land use and management
The SBT and Tayside present different and contrasting situations where various issues relating to land use and management were examined. The SBT was on a relatively contained site where there is a significant forestry operation managed by FCS, and where biodiversity conservation and visitor recreation management are significant factors. On Tayside the catchment area is much larger, with extensive areas given over to agriculture and other land use activities.
On Tayside the experiences of local land users with beavers on their land were recorded by the TBSG using questionnaires. Concerns such as the damming of drainage channels and burrowing into flood defence banks were identified (TBSG, 2015). There were also some preliminary trials of mitigation techniques such as tree guards, and flow control devices for beaver dams.

One of the key issues that land users raised is the extent to which beavers might be managed in the future if their long term presence is eventually approved, and they are added to Schedule 2 of the Habitats Regulations 1994 as a ‘European Protected Species’. To help answer that question, SNH commissioned a project on behalf of the NSRF. The work was carried out by legal and conservation specialists based at the University of Aberdeen, and involved assessing the extent to which protected species had been the subject of conservation translocations in Europe, and examining some specific case studies of the more contentious species such as wolf, lynx, sea eagle and beaver (Pillai et al., 2012).

The case studies found that some of these reintroduced species had their populations or habitats controlled, when their numbers were healthy and thriving and there were conflicts with other land uses. Under current European laws, legal protection for protected species is strict, but member states may ‘derogate’ from the rules, subject to satisfying certain conditions, including that the species concerned are judged to be in favourable conservation status. Such derogations allow control of a particular protected species, and are regularly used in species management throughout Europe. The report recommended that the key to meeting the EU legal requirements is to have a national species management strategy in place, which outlines the needs and threats faced by the species, and the problems it may pose for human activities.

There is also the related issue of improving the security of captive beavers to try and minimise the risk of accidental escapes, which in turn might lead to ‘uncontrolled’ reintroductions and conflict. This was looked at through a combination of improved husbandry advice, discussions with owners and consideration of the conditions that are attached to licences for the keeping of beavers.

Details of specific beaver management techniques, the legal implications relating to beavers and their management, and the type of issues that might need to be covered in any future national beaver management strategy, are covered in more detail in the SNH Beavers in Scotland report (Gaywood, 2015).

Further Work

SAF finished in March 2012 but the SBT, and other beaver projects and initiatives described above, carried on until May 2015. The final reports associated with the work of the SBT, TBSG and BSWG and other initiatives are now available via the SNH website. In June 2015 SNH provided the Minister for Environment, Climate Change and Land Reform with a package of the relevant reports produced by various authors, together with the Beavers in Scotland report, which summarised the key findings, identified the main issues and examined a range of potential future scenarios for the future of beavers and beaver reintroduction in Scotland. This was used to support the decisions on the future of beaver reintroduction to Scotland, including the beavers currently present at Knapdale and Tayside.

The NSRF have published a Scottish Code for Conservation Translocations and associated Best Practice Guidelines (National Species Reintroduction Forum, 2014). The project was led by SNH in partnership with the Royal Botanic Garden Edinburgh. The aim of the Code is to guide the process of evaluating whether a translocation is appropriate, and if so, how to increase the likelihood of successful outcomes, and reduce the likelihood of problems and conflict. The Code is consistent with the revised IUCN Guidelines for Species Conservation Translocations (IUCN, 2012). The experience of the beaver reintroduction in Scotland, and of other species translocations, have helped to inform the content of the Code. Any new beaver conservation translocation proposal will need to address the principles set out in the Code, and any further releases would need a licence from SNH.

On 24 November 2016, Roseanna Cunningham MSP, Cabinet Secretary for Environment, Climate Change and Land Reform, announced that the Eurasian beaver will remain in Scotland. Efforts will now need to focus on working with key stakeholders to develop a planned and strategic approach to future beaver management.
Further Information

- www.scottishbeavers.org.uk – SWT and RZSS website for the SBT.

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The SAF Partners

Project manager partners
- Royal Zoological Society of Scotland
- Scottish Wildlife Trust

Landowner partner
- Forestry Commission Scotland

Independent Monitoring Partners
- Argyll and Bute Council
- Argyll Fisheries Trust
- British Dragonfly Society
- Historic Scotland
- James Hutton Institute
- Royal (Dick) School of Veterinary Studies
- Scottish Environment Protection Agency
- Scottish Natural Heritage
- Scotland’s Rural College
- University of Oxford
- University of Stirling

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework

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Summary

- The great crested newt is a threatened species across Europe. Though the UK is a stronghold, the species is not in favourable condition even here. Scotland is at the edge of its range with a limited, patchy distribution.
- Its decline has been linked to the loss of breeding ponds and the fragmentation of habitat, often due to development. There has been a good deal of study of its habitat requirements in its core British range, and guidance had already been produced on designing and managing ponds and their surroundings.
- A scoping report in 2006/2007 gathered together a compendium of possible habitat restoration and creation projects. The aim was to extend known populations within their range of natural dispersal and no translocations were considered.
- From 2007 to 2009, projects to restore and create ponds and associated terrestrial habitat were funded in southern and central Scotland. A project at Mount Lothian in Midlothian was the largest in scale.
- In 2009 the Scotland Rural Development Programme (SRDP) was established by the Scottish Government, and included options under its Rural Priorities Programme for funding conservation work. However, direct funding of habitat creation or restoration from the Species Action Framework (SAF) project was no longer considered appropriate. Instead, SAF project funds were used to sponsor the Amphibian and Reptile Conservation Trust (ARC) to develop a leaflet to guide land managers towards benefiting great crested newts under the SRDP scheme. In addition, ARC and Farm Environment Ltd. carried out a pilot scheme in East Lothian to explore options for great crested newt conservation work under SRDP.
- The SRDP proved not to be effective in its original form. Though work for great crested newt can be simple and cheap, the SRDP protocols meant that such projects were either not considered worth the effort, or became forgotten within larger projects. However, work carried out under SAF helped inform the next stage of SRDP, which has now been launched.
- Although the SAF is complete, it has led to a series of further pond creation and restoration projects across the great crested newt’s Scottish range.
- The project, and its successors, have benefitted immensely from the knowledge and enthusiasm of landowner and managers. It has also been supported by volunteers, particularly members of local Amphibian and Reptile Groups. The ongoing survival of the species in Scotland is likely to rely on the continuation of this broad support.
- Overall, the project exceeded its goals: we now have around 200 occupied recorded breeding ponds in Scotland, double that at the beginning of the project and more than the target of 150. The project team created or restored 89 ponds and their surrounding habitat, rather than the target of 20.

Introduction

Species background

The great crested newt (Triturus cristatus) is the largest of the three British newt species, with an adult length range of 90-170 mm (Fig. 1). The adult male has a jagged crest along its back which decreases in size outside the breeding season. Both sexes are black to dark brown in colour, with black blotches. They have white stippling on their flanks and a vivid orange belly, patterned with irregular black spots. The skin is granular giving the species its alternative common name of warty newt (Fig. 2).
Fig 1. The great crested newt *Triturus cristatus*. © Chris Dresh/ARC

Fig 2. Male great crested newt. Note orange underside, ‘warty’ skin and distinct break in the crest where tail meets abdomen. © Chris Dresh/ARC

Why was this species on the Species Action Framework list?

Great crested newt met criterion 1a of the SAF as a species for conservation action (SNH, 2007) because Scotland (and Britain as a whole) is a European stronghold for this species, there has been evidence of serious decline across Europe and there is a continuing threat to the species. Work elsewhere in Britain had shown that targeted work for the species can be effective in areas where the newts can easily disperse to the newly created habitat (Langton et al., 2001). Volunteer conservation groups can make a significant difference in creating or restoring breeding ponds and surrounding terrestrial habitat. Thus raising awareness of biodiversity issues more broadly was important. (Fig. 3).

Fig 3. Pond restoration. This work is often suited to volunteer effort. Work should be carried out during winter months when the newts are not present in the ponds. © Peter Leach/Technical & Safety Services

The great crested newt was identified as a Priority Species under the UK Biodiversity Action Plan (UKBAP) and is on the Scottish Biodiversity List. It is also on Annexes II and IV of the EC Habitats Directive. It is designated as a European Protected Species on the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended).

Habitat, distribution and abundance

The great crested newt spends the bulk of its life on land but is dependent on small- to medium-sized freshwater ponds to breed, occasionally using the margins of larger lochs. Naturally a creature of rough grassland, scrub and woodland, the species has long been associated with lowland farmland but has also found a niche in former (and current) mineral workings and other ‘brown field’ habitats (Jehle et al., 2011).

While most animals spend their terrestrial life within 250 m of the breeding pond, enough move further afield to make 500 m a sensible habitat buffer around a pond for management purposes, and dispersal of around 1,000 m can occur. It is crucial that these habitat components are appropriately linked by areas conducive to newt movement,
as this will permit migration between key areas. Studies have shown that the density of ponds may be important to the long-term survival of populations (Griffiths and Williams, 2000) and for this reason habitat creation should focus on groups of ponds, rather than individual ponds.

At the European level, the great crested newt is a threatened species and is suffering from declines in many parts of its range. Scottish populations are thought to be restricted to Dumfries and Galloway, the Borders, the Central Belt, and the area around Inverness. A 1996 national survey located 83 ponds in Scotland with great crested newt populations (Alexander, 1997). Subsequent work initiated by the SAF project, using local surveys and environmental assessments linked to development proposals, brought this number up to around 100. Further examination of existing data and a survey project running parallel with the SAF work has increased this number to around 200 ponds, but all within a distribution already defined by the 1996 work (Wilkinson et al., 2014).

This species is widespread and may be locally numerous in parts of lowland England and Wales but is absent or rare in Dyfed, Cornwall, and Devon. It is absent from Northern Ireland.

**General ecology**

Great crested newts are largely nocturnal, and prey on a wide range of invertebrates. During the day they hide in damp places such as under logs or stones.

They emerge from hibernation in spring and migrate from their terrestrial habitat to breeding ponds. Migration is temperature dependent and occurs when the night-time temperature reaches about 5°C; emergence is often associated with humid conditions. Males display to females in an elaborate underwater courtship. A female can lay 200-400 eggs over the season. Eggs are usually wrapped in the leaves of aquatic vegetation. These hatch into tiny larvae, which are carnivorous.

After breeding, the majority of adults return to their terrestrial habitat, though some juveniles remain in the pond throughout the summer.

**History of decline, contributory factors and current threats**

The species has suffered a decline in recent years, with studies suggesting a 50% loss of populations between 1960 and 1975 in Britain (Beebee, 1975), and subsequent studies estimating losses of 0.5% (Corbett, 1994) to 2% per year (Swan and Oldham, 1989). It is estimated that there are about 60,000 occupied ponds within Britain (Wilkinson et al., 2014), although only a small proportion of these have been identified. The British population is amongst the largest in Europe, where it is threatened in several countries (Edgar and Bird, 2006).

The great crested newt is principally threatened by the destruction of its breeding ponds and by pollution, but other factors are important. Studies in Scotland have confirmed work elsewhere which has shown that the introduction of fish to breeding ponds is catastrophic, as fish eat newt eggs and larvae. Ponds which become over-shaded by vegetation as a result of neglect are unlikely to support this species. The loss and fragmentation of terrestrial habitat also has a negative effect, as adult newts forage and hibernate on land. Populations in isolated ponds are more likely to die out over time as a result of chance events (Griffiths and Williams, 2000).

**Aims**

**Aims for 2007-2012**

These were drawn from the UKBAP objectives for Scotland as they stood in 2007 (JNCC, 2007; ARC, 2007):

- To increase the number of occupied recorded breeding ponds from 100 to 150, and ensure new ponds are created as components of pond clusters.
- To improve/restore 20 current breeding ponds and surrounding habitat to ensure medium-long term viability for populations.
Management Action

Summary of the main actions undertaken

- **Scoping report** commissioned by SNH, completed by the Herpetological Conservation Trust (HCT, now Amphibian and Reptile Conservation, ARC).

- **Pond creation and restoration** carried out in East Lothian (11 ponds), West Lothian (9), Edinburgh (4), Midlothian (32), Falkirk (12), North Lanarkshire (5), Borders (13) and Galloway (3); a total of 89 ponds.

- **Advice document** for land managers and their agents on taking action for great crested newt under the SRDP produced by ARC.

- **Pilot scheme** to explore the mechanisms for funding under the SRDP carried out in East Lothian by The Farm Environment and ARC.

- **Survey** of areas where modelling suggested new populations of great crested newt might be found.

Specific actions under the SAF project

2007

- Collation of data on known populations and production of a strategic compendium of potential projects under SAF, carried out by HCT.

- Pond creation work, North Lanarkshire – carried out by HCT.

- Pond creation work, Borders – carried out by the Tweed Forum and Borders Amphibian and Reptile Group (BARG).

2008

- Pond creation and restoration work, Falkirk – by Falkirk Biodiversity Partnership, Lothian Amphibian and Reptile Group (LARG) and the British Trust for Conservation Volunteers (BTCV, now TCV).

- Pond creation work, City of Edinburgh, Midlothian and West Lothian – by Lothians Farming and Wildlife Advisory Group (FWAG) and Lothian Amphibian and Reptile Group (LARG) with contributions from Midlothian Council, West Lothian Council and City of Edinburgh Council.

2009

- Pond creation work, Lothians - by Lothians FWAG, West Lothian Council and LARG (other planned work lost after financial collapse of FWAG Scotland).

- Pond creation work, Borders – by the Tweed Forum and Borders FWAG.

- Pond creation work, Wigtownshire - by Culmore Bridge Cottages.

- Funding of conservation activities passed over to SRDP.

2010

- Information sheet for land managers and their agents to encourage use of SRDP to carry out conservation work for great crested newts produced by ARC (Wright and Seymour, 2011) (Fig. 4).

Fig 4. A Guide to Rural Priorities and Land Managers Options for Great Crested Newts. © ARC

2011

- The Farm Environment Ltd. (Director Tony Seymour, the former Lothian FWAG advisor) and ARC carried out a pilot scheme to investigate how farmers could carry out work for great crested newts under the SRDP scheme. Strategic work to identify the best places to carry out great crested newt work was instigated but it was found that the SRDP bidding process was too cumbersome and that the options available were not satisfactory. However, some work was carried out by
landowners through their own enthusiasm. The benefit of training was identified and two training days on practical habitat creation were undertaken, with particular emphasis on training for excavator drivers (Fig. 5).

Fig 5. Training on pond creation. Courses were aimed at excavator drivers and other practitioners. © Tony Seymour/The Farm Environment Ltd

Case study: Habitat creation work at Mount Lothian

The principles used in the SAF project are best described in an outline of the largest single project in Midlothian, at Mount Lothian near Howgate.

The potential for great crested newt work at this Midlothian site was identified in 2007 and implemented by Tony Seymour, then the Lothian farm conservation adviser for FWAG Scotland. Two populations at this site were well known in the survey literature, both being ponds in historic limestone quarries.

Before work began, Herbertshaw Quarry held a single, relatively large and deep pond whereas the more extensive Black Mount Quarry contained several shallower ponds. The whole site is at a relatively high altitude for this species in the UK, at 200–280 m above sea level. The surrounding habitat includes unimproved and improved grassland, rushy pasture, mire and peaty moorland. The exposure of limestone bedrock by past quarrying activities had helped to make the site suitable for great crested newts by reducing pond acidity.

The ethos of the SAF great crested newt project was not to translocate newts into novel areas but to create or restore suitable habitat within the natural range of dispersal of the animals in existing loci, so allowing them to expand their range naturally.

Site investigation, and liaison with the local farmers, identified suitable locations for new, potential breeding ponds, and potential routes for the creation of ‘corridor’ habitat. Twenty nine new ponds were created, and one restored, with 370 m of habitat fenced off to act as migration corridors.

The ponds were created using a 13 t excavator on low-pressure treads. Key to the success of the project was the support, interest and engagement of the farmers, and the services of sympathetic and competent excavator drivers. No pond liners were used but the ponds were carefully sited to utilise the natural water table. In a few instances some planting of water forget-me-not (Myosotis scorpioides) took place but, in the main, the ponds were not planted-up with aquatic vegetation but were left to develop naturally.

LARG surveyed a selection of the ponds in 2008, with the intention of follow-up survey after five years. This was superseded in 2012 when the site became subject to environmental audit monitoring for a proposed wind farm development adjacent to the site. This has ensured a high level of post-project monitoring and created a good picture of the development of the scheme.

Thirty ponds were created or restored in the winter of 2007/08. Great crested newts were found in two of the new ponds in the summer of 2008, 60 m and 120 m to the east of the established population at Herbertshaw Quarry. Since then they have been found in six of the new or restored ponds with breeding confirmed in four. To date, no colonisation has been observed in the ponds to the east of Black Mount Quarry.

In broad terms the distribution of the breeding population appears to be expanding by about 100 m/year, given suitable terrestrial habitat and ponds. During this time the population in the original pond appears to have declined, probably as the result of an unauthorised fish introduction.

Great crested newt survey

Increasing our knowledge of great crested newt breeding sites was one of the objectives of the SAF. This would inform conservation of existing populations and help target areas for pond creation and restoration, particularly those sites which might
link existing populations, thereby reducing extinction risks. Running parallel with the SAF project, SNH and ARC carried out a survey of great crested newt distribution in Scotland (Wilkinson et al., 2014). Building on the 1996 survey across Scotland and recent records, the work aimed to assess the distribution and status of the great crested newt in Scotland by developing a predictive model based on current knowledge and by testing the model through field survey.

Two seasons of survey work were undertaken in 2010 and 2011. One-km grid squares containing records were interrogated for land cover and environmental variables. The upper and lower limits for each environmental variable were then used to filter 1-km grid squares in Scotland. This aimed to remove squares with unsuitable habitat (hence the name removal modelling) and conversely identify squares with suitable habitat within statistical limits (Wilkinson et al., 2011). This was further refined in 2010 to suitable squares within 5 km of known great crested newt records and in 2011 to squares with a high density of ponds. Surveyors were sent out to ponds in these squares. Out of a total of 272 ponds only five new great crested newt populations were discovered. Whilst this may have been due to poor seasonal conditions for breeding or mis-timed survey work, the conclusion has been tentatively drawn that the distribution of the great crested newt in Scotland is already well known.

Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

Practices for pond and habitat creation were well established, so practical work could start straight away. Natural dispersal was favoured, so ponds were created within the dispersal range of existing populations, allowing colonisation well beyond the timescale of the SAF project. The results at Mount Lothian have helped to confirm that great crested newts will radiate out from an existing population centre and colonise new ponds when they are created.

A major change of tack was necessary in 2009 when funding of proactive work was transferred to SRDP. Since pond creation could no longer be funded directly, attention was turned to encouraging work under that scheme. However, the rate of uptake of options for great crested newt during the first stage of this scheme was disappointing. Modifications to the scheme will be necessary for it to work, in terms of the scheme structure and/or its promotion among land managers.

Future recommendations

Effective conservation needs to be based on evidence, and new ways of understanding the species ecology are helpful. For example, predictive mapping, coupled with local advisory services, could be a valuable tool for the strategic targeting of resources under the next stage of the SRDP.

There still remains a need for survey to find new sites and, where resources exist, monitor known populations. At present much of this work relies on the skills and dedication of volunteers across Scotland and on the support and cooperation of landowners and managers. New techniques such as eDNA, where samples of pond water are analysed for environmental DNA, are also being trialled in Scotland as part of a coordinated approach with scientists elsewhere in Britain and Europe.

New and ongoing work since SAF ended

In 2012 it was recognised that SRDP had not served the great crested newt well and there was justification for a return to directly funded work, as had happened in the early years of SAF. In 2012 pond creation was carried out in East Lothian and further ongoing work is described below.

This work was considered a stop-gap between the first and second tranches of SRDP. Work carried out under SAF has helped to inform the next version of the Scottish agri-environment programme.

Understanding habitat requirements

While the preferred aquatic and terrestrial habitats of great crested newts in their core range are well understood, anecdotal evidence suggested that the species’ requirements may be different at the edge of its range in northern Scotland. SNH worked in partnership with Salford University and Àlex Miró of the Centre for Advanced Studies, Blanes (Spanish Research Council) to build on surveys carried out by members of the Highland Biological
Recording Group (HBRG). This project looked at all known native sites in the Highlands and Moray as well as surveying for new sites. The study characterised features associated with the occurrence and persistence of breeding populations. This work is now being used to target pond creation work in the region.

Pond creation
There have been two pond creation schemes in the Highlands and Moray, based on the approach used in the SAF project and drawing on the findings of the study mentioned above. In the autumn of 2014, Forestry Commission Scotland created or restored a total of 14 ponds in the Strathpeffer area. One of these ponds was colonised by great crested newts within six months of its creation, and over half of them already have other breeding amphibians.

In March 2015, SNH, working with Tony Seymour (The Farm Environment Ltd), created seven new ponds and improved a further two for great crested newts on the Black Isle. They also created a new lined pond at a golf course in Forres and worked to improve a known breeding site which was becoming shaded-out. As well as providing potential new breeding sites, the aim was to reconnect populations that genetic studies have shown to have formerly been connected (O’Brien et al., 2015). While it is too early to assess their effectiveness as breeding sites, the project garnered a good deal of local publicity and again highlights the importance of working with land managers.

SRDP
Tony Seymour is working on a new guide to Agri-Environment Climate Scheme (AECS) options for great crested newts. The guide explains what farmers can do to support these animals and how to go about applying for the scheme.

Further Information

Amphibian habitat management handbook (2011) – Published by The Amphibian and Reptile Conservation Trust.

Great crested newt mitigation guidelines (2001) – Published by Natural England but applicable to all GB. Revised guidelines for Scotland are currently being prepared by SNH.

Key Management Messages

- Creating networks of ponds, ideally within 100–250 m of each other, is key to supporting resilient populations of great crested newts. These ponds should be connected by favourable habitat to allow colonisation and reduce the risk of inbreeding and local extinction.
- Ponds should be between 200-600 m² in size, though it is better to have a group of smaller ponds than a single large one.
- Pond should not be stocked with fish as these prey on newt larvae.
- Pond creation is a relatively low-cost operation that can produce quick results for newts and other wildlife. By working with the natural lie of the land, ponds can be made which do not need liners and in most cases there is no need to plant them up: plants will colonise naturally.
- Terrestrial work for other wildlife, such as beetle banks and grass strips in arable fields, and woodland creation, can also benefit great crested newts as long as this does not lead to the pond becoming shaded.
- The future conservation of this species relies on the cooperation and enthusiasm of land managers and volunteer groups.
References


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The SAF Partners

• Scottish Natural Heritage
• Amphibian and Reptile Conservation
• The Farm Environment
• Tweed Forum
• The Falkirk Area Biodiversity Partnership
• City of Edinburgh Council and Edinburgh Biodiversity Partnership
• West Lothian Council
• Midlothian Council
• Lothian Amphibian and Reptile Group
• Culmore Bridge Cottages

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

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Summary

• The Greenland white-fronted goose was listed for ‘conservation action’ within the Species Action Framework (SAF) because of significant declines in its small wintering population since the 1990s.

• Declines in numbers in Scotland have primarily occurred because of decreases in reproductive success on the breeding grounds in Greenland.

• The focus of the SAF project was to promote international co-operation for the conservation of this population and to address internationally agreed actions relevant to Scotland.

• An international action plan was developed in collaboration with scientists, conservation practitioners and statutory authorities from Greenland, Iceland, Ireland and the UK. It was adopted at the 5th Meeting of Parties of the Agreement on the conservation of African-Eurasian migratory waterbirds (AEWA) in May 2012, and has provided a catalyst for significant international conservation action.

• In Scotland, work on priority actions was undertaken through SAF including:
  – A project that prioritised small and vulnerable wintering flocks for conservation action, and provided site-specific and generic management suggestions. In tandem, Scottish Government has prioritised Greenland white-fronted geese within its goose management policy and identified the need for management of habitats for vulnerable wintering flocks. Work is underway to establish the best means of habitat management.
  – Attempts to mark geese in Scotland with the aim of better understanding their survival and movements. Despite significant effort at three sites, catching was unsuccessful. Resources in 2012 were therefore devoted to catching geese as they staged in west Iceland, and 68 birds were successfully marked, some of which have since overwintered in Scotland. Further, SAF provided the impetus for catching on Islay, where over 50 geese have been marked since the end of the project.
  – Contributions to continuing research to better understand why breeding success in Greenland has decreased in recent years.

• A web-based inventory has been developed to provide detailed, yet easily accessible, information on numbers, status and distribution of all wintering sites in Scotland.

Introduction

Species background

The Greenland white-fronted goose (Anser albifrons flavirostris) breeds in west Greenland and migrates via Iceland to winter exclusively in Ireland and Britain. During the 1950s, the population was estimated at 17,500-23,000 birds, but this had fallen to 14,300-16,600 by the late 1970s (Ruttledge and Ogilvie, 1979). Annual censuses of all known wintering resorts since that time provide more confidence in changes in overall abundance, and showed a steady increase following cessation of hunting throughout the wintering grounds since 1982/83 to a peak of 35,700 birds in 1999 (Fig. 1). Since the mid-1990s, the population has declined steadily. Autumn hunting in Iceland was stopped in 2006, with the result that numbers have more or less stabilised since. The winter population in 2012/13 was 22,200 individuals (Fox et al., 2013).

Fig 1. Graph of the global population size of Greenland white-fronted geese, 1982/83 to 2012/13 (squares), based on coordinated spring counts on wintering grounds. Open squares represent estimates where counts were missing. Annual spring counts from the most important Irish (Wexford Slobs) and Scottish (Islay) sites are also shown (closed and open circles respectively). Arrow indicates cessation of hunting in Iceland.

Source Greenland White-fronted Goose Study (GWGS)/National Parks and Wildlife Service (NPWS).

Since the mid-1980s, repeated observations of geese individually marked with neck collars have provided invaluable detail about survival and breeding success (Fig. 2). These confirm that a low proportion of sexually mature birds survive to breed, even during years of population growth as in the 1980s and early 1990s. Annual survival has not changed since the 1980s, so the decline in numbers since the late 1990s has been the result
of poor breeding success failing to replace natural losses. The cessation of autumn hunting in Iceland helped to stem the overall decline in the population. The increase in winter 2010/11 was the result of an exceptionally good breeding season in 2010, when geese returned with more young than in any year since 1984. In the following autumn, unusually mild conditions kept many geese in Iceland until very cold conditions forced them to leave into unfavourable winds. Many birds were blown off course and failed to reach their normal winter quarters. This resulted in the reduced count of 22,200 individuals in 2012/13.

Fig 2. Greenland white-fronted geese in flight, west Iceland. The lower bird has a numbered neck collar.

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**Why was this species on the SAF list?**

The Greenland white-fronted goose qualified under criterion 1a of the Species Action Framework for conservation action because of its significant decline. It also qualified under criterion 3a, as being the focus of conflicts where coexistence is difficult to achieve. It is listed on Annex I of the EC Birds Directive and on the Scottish Biodiversity List (Scottish Natural Heritage, 2007).

Although conditions on the winter quarters and spring staging areas in Iceland and Greenland probably affect the condition of individuals and their ability to breed in the subsequent summer, it is evident that population decline was mainly due to factors on the breeding grounds in Greenland (Fox et al., 2012). We therefore sought international collaboration to understand the causes of decline in breeding success and to identify measures to address these. This was especially important since a draft flyway plan, developed from an international workshop convened by the Irish Government in 1992, was never formally ratified, despite having been accepted by the international Range States involved (UK, Ireland, Iceland and Greenland). The SAF listing of this goose was therefore unusual, as the key work needed would be undertaken outside Scotland, with the main aims of re-establishing international collaboration, and agreeing key research, monitoring and management, through a formal action plan.

**Habitat and distribution**

The geese have a distinctive distribution in Ireland and Britain that reflects the distribution of oceanic patterned mires. These peatlands are the traditionally used feeding habitat, with the geese foraging by extracting below-ground overwintering organs of bog plants in mire pools and *Sphagnum* moss carpets, which in the mild oceanic climate do not often freeze in winter.

Fig 3. Map of known regular Greenland white-fronted goose wintering resorts used since 1982/83. See Stroud et al. (2012) for details of each site and information about site-safeguard. Symbol size reflects flock size as of spring 2008.

Source: GWGS/NPWS data.
Many of the geese have abandoned these traditional feeding grounds over the last 40 years to exploit low-intensity farmland, where they forage in a similar way, but they also increasingly graze native and managed grass species (Fox, 2003). The population is now confined to about 80 regular resorts on the wintering grounds in the UK and Ireland (Fig. 3). In spring, geese depart increasingly earlier for staging areas in south and west Iceland (Fig. 4) where they remain until the beginning of May (Fox and Walsh, 2012; Fox et al., 2012).

**General ecology**

Since the early 20th century the geese have foraged increasingly on agricultural habitats (Rutledge and Ogilvie, 1979; Fox et al., 2005). In the 1950s, almost half the known wintering flocks used peatlands (often as daytime feeding areas), but less than 10% do so now, and mostly as nighttime roosts rather than as primary feeding sites. While many flocks still exploit rushy pasture and low intensity grassland, the population increasingly exploits spilled grain in autumn and early winter and moves to intensively managed, reseeded grassland for most of the winter, supplemented (where available) by root crops in midwinter, when grass growth-rate slows. Interestingly, those flocks using the most intensively managed agricultural land show greater breeding success than those few that still remain on traditional wetland habitats (Fox et al., 2005). This habitat shift is also evident on staging areas in Iceland where, in recent years, an increasing proportion of geese forage on managed hayfields, which seemingly offer a far more profitable food source than the traditional wetlands formerly exploited. Only on the breeding grounds in western Greenland, where there is no agriculture anywhere in the breeding range, are the geese still restricted to traditional wetland food resources.

**History of decline, contributory factors and current threats**

Co-ordinated counts throughout the winter range were not available before 1982, when the network covering all known wintering sites was first established in Britain and in Ireland. Subsequent counts showed increases at the two numerically most important wintering sites: Wexford Slobs in south-east Ireland, and Islay in the Inner Hebrides (Fig. 1). These sites have together consistently supported approximately two-thirds of the global wintering population since 1982/83. During the same period, many of the internationally important roosts and staging areas were protected by site safeguard, in Scotland through classification as EU Birds Directive Special Protection Areas (SPAs) and/or notification as Sites of Special Scientific Interest (SSSIs). Large areas of the breeding grounds were protected as Ramsar wetlands of international importance. The protection from hunting, in particular, enabled the population in Scotland and Ireland to increase by 5-6% per annum. During the late 1980s and early 1990s, when breeding success was well above 10% each year, the kill in Iceland was ‘sustainable’ in the sense that 3,000 birds could be shot there annually without preventing the ongoing population increase. However, when the production of young fell consistently below 10% per annum from the mid-1990s, the balance of production over death rate was no longer positive and the population started to decline. This explains why, after six years of decline following the 1999 peak count, cessation of hunting in Iceland allowed the population to become fairly stable: low breeding success was now balanced by enhanced survival.

Human causes of mortality have been minimised with the geese effectively protected from hunting through most of their range. So what is causing the consistently low reproductive success? Several possible explanations have been put forward. The first relates to weather in west Greenland, where long-term cyclic changes in pressure systems mean that since the mid-1990s there has been substantially more precipitation in March-May. This has led to two to four times as much snow in spring when the geese arrive from Iceland. Breeding success is inversely correlated with spring precipitation but positively correlated with temperatures later in the season. Hence in recent
years, with high spring snow and cool summer conditions, breeding success has been poorer than in the past (Boyd and Fox, 2008). Canada geese \( \textit{Branta canadensis interior} \) have increasingly colonised west Greenland from North America, and these larger and generally more aggressive colonists may be competing for the same food as the Greenland white-fronted goose. There have been no intensive studies in the period prior to nesting, although there is some evidence that this is the case later in the summer during the moult. There are areas where increases in Canada geese have occurred as white-fronted goose numbers decline. If the poor breeding success is the result of weather and growing numbers of Canada geese in Greenland, there may be little we can do beyond managing the other constraints on the birds (Figs. 5 and 6).

**Aims**

**Aims and objectives for 2007-2012**

- To develop an action plan for the conservation of Greenland white-fronted geese in collaboration with a range of bodies across relevant states.
- To implement priority actions of the plan in Scotland.
- To manage information on the Greenland white-fronted goose population.

**Management Action**

**Summary of the main actions carried out**

- An \textit{International Single Species Action Plan for the Conservation of the Greenland White-fronted Goose} was developed at a workshop held on Islay in February 2009 and adopted by the fifth Meeting of the Parties to AEWA in May 2012 (Stroud \textit{et al.}, 2012).
- In Scotland, work on the priority actions within the action plan has included:
  - Identification of wintering flocks in Scotland that are most vulnerable to extinction, and their management requirements (Francis \textit{et al.}, 2011). Implementation of management agreements for these was also trialled.
  - Support for additional ringing of Greenland white-fronted geese, to enhance our understanding of differences in survival, reproductive success and dispersal between flocks.
  - Contribution to international research in Greenland to investigate causes of low reproductive output.
- The development of a detailed web-based inventory of flocks of Greenland white-fronted geese in Scotland, providing online data on census results, reproductive success and a range of site and flock based information for each wintering resort.
International action plan

The main aim of the SAF project was to develop an action plan for the conservation of Greenland white-fronted geese in collaboration with a range of bodies across its natural range. In February 2009 a three-day international workshop was held to agree conservation objectives and priority actions. Fifty experts from throughout the flyway, including international conservation organisations, stakeholder groups and representatives of the local farming community on Islay were brought together to discuss the range of threats and pressures acting on the population. Through this event an international single species action plan was developed, and it was adopted by the fifth Meeting of Parties (MoP 5) to AEWA in May 2012. It establishes an agreed international framework of conservation actions, including issues relating to research, site management and policy. A summary of conservation objectives and top priority actions is shown in the box below.

Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)

Summary of conservation objectives and top priority actions:

The long-term goal of this plan (by 2020) is to establish and then maintain the favourable conservation status of the international population of Greenland white-fronted geese throughout its global range. In the short term (by 2015), the aim is to identify the causes of current low productivity which is leading to a rapid decline of the population, and then put in place measures to address (to the extent that is feasible) these factors in order to halt and reverse the decline.

a. The top priority action is to investigate the factors acting on geese on the breeding grounds responsible for currently reducing the annual production of young:
   - Investigate and assess factors restricting productivity, through an international research programme, investigating a) potential competitive interactions with Canada geese in west Greenland; and b) consequences of greater spring snow-fall in recent years.

However, even knowing the causes of low productivity, it is unlikely that reproductive success can be enhanced in the short-term. Accordingly it is essential that measures are also taken to:

b. ensure that geese arrive in Greenland in optimal condition for successful breeding:
   - Develop the existing international network of conservation management areas, especially on the staging grounds, to ensure that all key sites are appropriately protected and managed.

c. minimise additional sources of mortality:
   - Take all possible steps to eliminate avoidable sources of mortality and disturbance, particularly shooting and collisions with man-made structures.

d. minimise impacts on geese at local scales (such as disturbance or changes in habitat) particularly for smaller flocks, or those with restricted distribution, so as to avoid further flock extinctions, to avoid further contraction of range; and
   - Assess the need for, and develop as appropriate, local habitat management measures on the wintering grounds so as to optimise quality of agricultural feeding areas, and thus avoid further flock extinctions.

e. maintain and further develop monitoring and research programmes so as to provide necessary data and information concerning the current conservation status of the population.
   - Maintain the long-term marking, re-sighting and counting programmes at the main Irish wintering site of Wexford.
   - Develop a complementary Scottish marking programme, at locations which allow for sustained resighting effort.
   - Maintain the annual international population census, improving coverage where deficient, and collecting more extensive assessments of age-ratios throughout the range.
A Steering Group of Range State and organisational representatives has been established that has met annually via teleconference since 2009, and this group will have a key role in guiding national implementation. Some of the key actions within the plan that have progressed since the Islay workshop include:

- Consultation in early 2013 by the Welsh Government on a proposal to remove Greenland white-fronted geese from the quarry list from 1 September 2013. The Welsh Government subsequently decided against provision of statutory protection for the geese.
- Designation of a 3,086 ha Ramsar site in western Iceland (Andakíll Protected Habitat Area, Andakíll, Hvanneyri) which includes the most important spring staging area in Iceland.
- Initiation of a PhD study covering ecology of flocks in Scotland, Ireland and west Iceland.
- Research on small flocks and their conservation needs in Scotland (below).

AEWA was considered to be the most appropriate mechanism for securing political endorsement of the action plan. Iceland became a Contracting Party of AEWA on 1 June 2013, but Greenland has yet to do so, although discussions continue with authorities there. Regardless of national accession status, the action plan can and does provide an internationally endorsed framework that can be used not only by AEWA Contracting Parties but by all others concerned with the conservation and management of this population.

**Progress on priority actions for Scotland**

The AEWA action plan provided an excellent basis for prioritising further work under the SAF. Of the priority actions identified within the plan, the most relevant for conservation action within Scotland was:

- To assess the need for, and develop as appropriate, local habitat management measures on the wintering grounds so as to optimise quality of agricultural feeding areas, and thus avoid further flock extinctions.

As such, work towards this action was the focus of much of the subsequent SAF project. However, additional priority actions supported through the SAF project included:

- Investigation and assessment of the factors restricting productivity in Greenland.
- Development of a Scottish marking programme for Greenland white-fronted geese.

The SAF work carried out to address these actions is outlined below.

**Management of small and vulnerable wintering flocks**

Management of feeding areas in Scotland previously focused on the larger wintering resorts of Islay and Kintyre, which held the majority of the Scottish wintering population, with additional management being undertaken at some sites by conservation organisations such as the Royal Society for the Protection of Birds (RSPB).

Norriss & Wilson (1988) showed that disturbance has been an important factor affecting rates of population change in Ireland, with flocks with a restricted feeding range being more likely to suffer local population declines as a result of disturbance. Geese show high levels of site loyalty with individuals often showing preferences for very restricted parts of the potential feeding area (Wilson et al., 1991) so there is little chance or re-colonisation of deserted sites, nor large scale immigration from other areas to support declining flocks. Consequently small flocks with a restricted feeding range can be especially vulnerable to changes in habitat management and disturbance, potentially causing population decline, local extinction and range contraction. In Scotland eight traditional wintering flocks are already extinct with many others at high risk of extinction (Stroud et al., 2012).

Consequently the AEWA plan identified the need to secure suitable wintering habitat for the smaller flocks and those with a restricted distribution. There was therefore a need to:

- Identify the most vulnerable wintering flocks in Scotland.
- Consider appropriate site-specific management actions.
- Draw wider conclusions about the management requirements of this population.

**What do we need to do for vulnerable flocks of Greenland white-fronted geese?**

Under the SAF project, the Greenland White-fronted Goose Study (GWGS) and Wildfowl & Wetlands Trust (WWT) (assisted in two areas by RSPB Scotland staff) undertook a study of these smaller sites to address these issues (Francis et
During the winters of 2009/10 and 2010/11, 19 sites across the Scottish winter range were visited (Figs. 7–10). Land use and other factors were assessed in the field, and historical information, agri-environment participation and comments from local counters, Scottish Natural Heritage (SNH) staff and farmers were collated.

Figs 7–10. Wintering habitat for some of the small flocks of Greenland white-fronted geese in Scotland.

The factors affecting the demographics of small flocks are operating against a background of overall population decline and complex ecological conditions throughout the annual cycle, and existing knowledge of many wintering sites and their land use history was poor. A ‘snapshot’ visit, together with other background information, could only partially contribute towards an understanding and diagnosis of any site-related problems. Nevertheless, this is the first time that an exercise of this kind had been undertaken and much useful site-related information was gathered.

In most cases, there were no obvious reasons why goose numbers at any of the small sites should be low or declining, and there were no clear habitat-related limits to suitable areas for feeding or roosting. Often, very small numbers were found within an extensive landscape of suitable or even apparently optimal habitat.
However, some characteristics of areas used by Greenland white-fronted geese were identified. They appeared to select improved land, especially older improved pastures that were ‘green-yellow’ in appearance rather than bright green, with shorter swards and medium to high grazing intensities (possibly grazed preferentially by sheep). Preferred fields had little or lower cover of rushes (Juncus species) compared to those available to the geese generally, and there was a slight preference for fields with seasonally flooded areas rather than permanent standing water. Thirteen of the 19 sites had active agri-environment measures operating over some part of the land used by the geese, though none of these was aimed at goose management. By frequency, the most widespread measures were open-grazed grassland and corncrake (Crex crex) management options.

Population size and trends at individual sites were analysed and sites were prioritised for conservation action. The top priority sites were considered to be Loch Ken, Stranraer, Colonsay and Oronsay, South Uist, The Loons (Orkney) and Moine Mhor. In this study there was a significant trend for the number of geese at larger sites to be declining more rapidly. We looked at threats and conservation designations across all sites but could find no clear relationships between these and the population trajectories.

There could be certain inherent biological properties of ‘small flocks’ that may affect the number of geese at these small sites, and it may well be that factors operating outwith the wintering range are most important. However, habitat change has also affected these areas, and recommendations were made for management actions (see next section) to benefit Greenland white-fronted geese, both generally and for the individual sites.

Actions at individual small sites are likely to depend on site-specific requirements, hence the idea of developing individual management plans. Issues that may need to be considered include:

1. Integration of Greenland white-fronted goose management on sites that are designated and managed for other natural heritage reasons. It is important to ensure that management aimed at the geese does not conflict with the conservation objectives for other species and habitats.

2. Consideration of agricultural land management, including issues such as reseeding, drainage and disturbance, as well as potential changes in stocking densities over the long term (such as reduction in numbers of grazing animals in the Western Isles to a point where insufficient grazing of favoured fields takes place).

3. Interactions with other goose species, either directly or indirectly through hunting disturbance of other species, as well as possible behavioural factors. Improving fields for Greenland white-fronted geese may have the additional effect of attracting increasing numbers of greylag geese (Anser anser) and/or Canada geese. Thus, a farmer may be reluctant to continue goose-grazing improvements for Greenland white-fronted geese if they also attract unwanted goose species.

4. Obtaining a better idea of field use at all the small sites. As shown above, our knowledge of this is often unsatisfactory, and local studies would help to improve management recommendations.

What is the best way to secure this management?

In light of the priority actions identified in the Action Plan, the 2010 Review of Goose Management Policy in Scotland (Crabtree et al., 2010) identified the management of small flocks of Greenland white-fronted geese as a priority. The Scottish Government response to the review stated that goose management should be adapted to prioritise goose populations in accordance with their status. Consequently Greenland white-fronted geese are highest priority for conservation management. Further, the Scottish Government specified that management should be undertaken for small and dispersed populations of these geese.

With both policy and practical support for the management of habitat for the most vulnerable wintering flocks in Scotland, a one-year trial of management agreements was undertaken to explore how habitat management could be delivered. There was a clear lack of uptake of agreements by land managers for small flocks during the trial period. A number of issues may have contributed to the lack of uptake, such as:

- Short period of agreements (one year) requiring more time and negotiation for less management and money than agreements covering longer time periods. This is frustrating and off-putting for land managers and for SNH area officers.

- Short lead-in times.

- Concerns from land managers about grazing pressure from resident goose populations (resident greylag goose and to a lesser extent Canada goose) impacting on their enthusiasm for managing for any goose species.

- Shortages of SNH staff at some locations.
• Conflict of management with other natural heritage interests and/or management.

However, it was considered that the overriding reason for low uptake was that land managers did not consider the payment levels to be worth the effort of entering a management agreement. Much of the management action that was feasible within a single year was rush-cutting of restricted areas, for which payments are relatively low. It is notable that the one site where there was uptake by farmers was also the only site where more significant work was proposed, with associated higher payment levels. At this site two out of three farmers took up the agreements offered.

Appropriate management of these sites needs close involvement of land managers, as goose distribution is very localised. Simplification of the process, such as could be achieved by establishing agreements that extend over several years or their incorporation within the Scotland Rural Development Programme (SRDP), may help. However, it is likely that, for sites where a low level of management is required and associated costs of management are low, other forms of incentive may be required to ensure uptake. Possibilities include:

• Making payments higher than the actual cost of management.
• Gaining non-monetary benefit from management (such as prioritisation of SRDP applications).

Management can take place through one of two mechanisms, SNH management agreements and SRDP. There is a need for careful consideration to ensure that wintering grounds for the most vulnerable flocks are managed appropriately.

Support for colour ringing

The recent decline of the Greenland white-fronted goose throughout its range has highlighted our lack of knowledge about the population and its needs. While the annual census network has been highly successful in counting numbers and sampling annual age ratios to track potential changes in reproductive output, measures of annual survival and emigration/immigration at specific sites in Scotland is lacking, because individual marking of geese has been mainly concentrated at one site in Ireland. It was for this reason that the Action Plan identified the development of a Scottish marking programme as a high priority action.

Under the SAF project a programme was supported to mark samples of Greenland white-fronted geese at a number of Scottish sites, to provide an annual comparison of survival rates and movements of a pool of marked individuals. This was a three year programme intended to generate age, sex and year-specific rates of site exchange and local survival, at sites where the local count network coverage was sufficient to ensure a high and constant level of individual resighting rates. The aim was to mark geese each year for three years at two locations where local observers were available to provide resightings, and to catch at least 35 birds at each location. Between 2009/10 and 2011/12 SNH provided funding that largely covered the travel and subsistence costs of volunteers.

Considerable effort was invested in the ringing programme. Attempts were made to catch geese annually in Caithness, Islay and Tiree, but despite weeks of preparatory survey and observation by volunteers, no successful catches took place. Logistic problems, difficulties with obtaining permissions to catch, bad weather and poor luck all conspired to result in no birds being caught and marked under the programme. However, 27 birds were caught and marked at Loch Ken in conjunction with the WWT over the winters of 2010/11 and 2011/12, 10 of which were fitted with GPS loggers to track their movements.

Given this lack of success in catching geese in Scotland over the three winters, it was reluctantly concluded that cannon-netting was too costly in terms of preparatory time and it may be more efficient to catch birds on the staging areas in Iceland. Thus 68 staging Greenland white-fronted geese were captured and marked at Hvanneyri in western Iceland in April and May 2012. Past observations of geese marked at this site show that some individuals winter in Scotland (Fig. 11). Work by WWT at Loch Ken indicated, however, that with enough knowledge of goose activity at a wintering site and adequate time to prepare the catch area, it is possibly to catch these geese in Scotland. SAF funding for this project was restricted largely to travel and subsistence costs, and as such relied heavily on volunteer effort to secure successful catches. The provision of full funding to cover the professional costs of preparing catch sites (perhaps in the region of two to three weeks per site) would have significantly increased the chance of catching geese at other sites. Despite the lack of success the impetus and experience gained during SAF-funded work has led to successful catching and marking of over 50 geese on Islay since the end of the project.
Investigation of the causes of low reproductive success on the breeding grounds was considered the most urgent priority by the Single Species Action Plan. As such GWGS, WWT and University of Exeter are funding and supporting research to address this, centred on a PhD studentship.

In 2010, an expedition to Isunngua, west Greenland studied the behaviour, feeding ecology and reproductive success of both Greenland white-fronted geese and the rapidly expanding population of Canada geese on the breeding grounds. Analysis of the results (Mitchell et al., 2011), supported by the SAF project, concluded that:

- In 2010, Greenland white-fronted geese arrived at the breeding grounds at least a week before the Canada geese.
- No nests of Greenland white-fronted geese were found, despite historical evidence of their occurrence, although data were collected on 34 Canada goose nests (Mitchell et al., 2011).
- Behavioural studies showed a lack of evidence for competition, aggressive encounters or displacement between the two species. It may remain the case that Greenland white-fronted geese have abandoned the area as a breeding ground because of competition with Canada geese, and that displacement through these mechanisms may have occurred at some time in the last 20 years.

Further, in 2010 the weather conditions in Isunngua and many other parts of west Greenland were warmer and drier than in recent years. Observations in the autumn and early winter suggest that 2010 was an exceptionally good breeding season for Greenland white-fronted geese with 22.9% young in sample flocks on Islay, the highest production since the record season of 1985. These observations support the theory that weather patterns are influencing productivity.

**Development of a web-based inventory of Scottish wintering sites**

Species can only be protected if the people influencing their status, whether land managers, developers, public bodies or others with an interest in their conservation, have knowledge of their status and distribution and an understanding of factors that may affect their populations.

Greenland white-fronted geese are particularly site-faithful within a very restricted wintering range. In light of recent population declines it was considered particularly important to disseminate information on the conservation status of these geese, and perhaps more importantly the areas where they occur, and details of site-specific population trends and threats. Therefore a web-based inventory of Scottish wintering sites for Greenland white-fronted geese was developed to:

- Make publicly available as much information as possible about this endangered population.
- Encourage open dialogue regarding issues, sightings, behaviour and any questions people might have about the geese and their effective conservation.
- Specifically create a robust and easily accessible register of sites and trends that will contribute towards international efforts to conserve the bird and develop a flyway management plan for the population.

This inventory provides an interactive map to locate local goose populations and provides detailed information on status, feeding and roosting habitats, site safeguards, and threats. Wider information on the status of the population and conservation work currently underway is also provided within the website.
Lessons Learnt, Further Work and Future Recommendations

- Although resource intensive, international collaboration and agreement on conservation actions has proved effective in prioritising actions at a country level and has resulted in significant conservation actions for Greenland white-fronted geese across their range. In a Scottish context, the development of such a plan has helped to prioritise this goose within Scottish Government policy as well as identifying the most important conservation actions.

- The process of developing a species action plan provides an opportunity to develop a shared understanding of the issues needing attention and their relative priority. Critically, as for other types of (e.g. site) management plan, it should be a dynamic document, updated, revised and adapted in response to circumstances. For Greenland white-fronted geese, although winter site conditions may not be the main driver of population change, it is important to ensure that local site conditions do not deteriorate. There is a need for smaller scale, flexible management arrangements to be put in place at the most vulnerable wintering sites as quickly as possible. All such areas should have a management plan aimed at the specific requirements of a particular flock, drawn up using local knowledge.

- A single year trial for testing management actions proved difficult to implement, and consequently provided no information on how management benefitted Greenland white-fronted geese. However it provided useful insights into the constraints on providing habitat management for these geese.

- There is a need to investigate the best mechanism for providing habitat management, as high levels of land-manager involvement are essential to secure the conservation of this highly geographically restricted population.

- There is a need to increase the number of marked birds in the Scottish population. This may not be possible solely through the use of volunteer effort and low level ‘transport and subsistence’ funding, as attempted through the SAF project, owing to the level of work required to secure successful catching of these birds. Consequently future catching attempts should be better resourced.

New and ongoing work since SAF ended

Following the recommendations of the SAF project and the key points from the planning process, WWT and Exeter University have funded a PhD and the candidate, Mitch Weegman, is now approaching the completion of his studies. The project aims to model the changes in abundance of Greenland white-fronted geese at the key wintering sites of Wexford and Islay, as well as to better understand the factors affecting changes in abundance at all known wintering sites. The project has also been highly successful in fitting logging devices to birds caught at Wexford and Loch Ken, to record behaviours and daily positions of individually tagged geese in order to understand the factors throughout the life cycle that determine whether a bird is successful at breeding. The reasons behind the low reproductive success of the population as a whole remain the key to understanding the causes of the declines in recent years, and it is only possible to unravel these secrets by following individuals that return to the winter quarters with young and those that do not, to contrast the differences.

Because the densities of Greenland white-fronted geese are now so low at Isunngua, it is proposed that future research in Greenland to investigate reproductive success of this population should focus on areas with higher breeding densities. This will however incur markedly higher costs and be logistically more complex.
Key Management Messages

- International collaboration and action planning through mechanisms such as AEWA can be a powerful mechanism for delivering conservation for migratory species.
- Where management of very localised areas is required for species conservation, making such management attractive to land managers is key to success.

Further Information

- http://gwfg-conservation.wikispaces.com – Website with links to the AEWA action plan as well as presentations and other materials presented at the preparatory 2009 international workshop, updates on international conservation action for the Greenland white-fronted goose, and a large amount of other research and conservation literature.
- www.greenlandwhitefront.org – Greenland White-fronted Goose Study website, including detailed information on work relating to the population. This website also holds the inventory of wintering sites in Scotland.

References


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**The SAF Partners**

- **Scottish Natural Heritage**
- **Greenland White-fronted Goose Study**
- **The Wildfowl & Wetlands Trust**

**The Species Action Framework Handbook**

This account comes from the *Species Action Framework Handbook* published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Red and Grey Squirrels

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Summary

The aim of the red squirrel work funded by the Species Action Framework (SAF) was to maintain the population of the species across its current range in Scotland, and to reduce the threat from grey squirrels. The red squirrel became a SAF species for conservation action because of its population decline over the past 50 years. The grey squirrel was also in the SAF programme as an invasive, non-native species because it threatens red squirrels by competitive replacement, and carries the squirrelpox virus that is fatal to red squirrels.

The initial focus of the SAF work was around Priority Woodlands identified by Scottish Natural Heritage (SNH) in 2005. Forestry Commission Scotland (FCS) subsequently initiated a programme of ‘stronghold forests’ with a view to creating a secure habitat resource for red squirrels across their range.

SAF funding also capitalised on earlier conservation action in different parts of Scotland supported by SNH funding by co-ordinating a large, collaborative partnership between government, conservation charities, landowners and individuals. The project, called ‘Saving Scotland’s Red Squirrels’ (SSRS), was launched in 2009, with the aims of:

- Halting the spread of grey squirrels northwards of a protection line in central Scotland, and outwards from Aberdeen.
- Containing the spread of squirrelpox virus in south Scotland.
- Gathering evidence to establish if targeted grey squirrel control is a cost effective and sustainable action for red squirrel conservation.

Good progress has been made against all of these aims, with the following highlights:

- Extensive networks have been established to deliver strategic grey squirrel control for the protection of red squirrel populations in the Highlands and north-east Scotland.
- In south Scotland these control networks have been reactive to the spread of squirrelpox virus. While control efforts have not been able to contain the spread of the disease, the project made good use of population modelling and disease surveillance in targeting limited resources to help slow the spread of the virus and enable red squirrel populations to recover after outbreaks.
- The project provided a focus and quality assurance process for gathering evidence to identify where publicly-funded grey squirrel control should be undertaken to benefit red squirrels most effectively.
- A suite of ‘stronghold forests’ has been identified and, following on from SAF, guidance has been produced on appropriate forest planning and management.
- Public awareness and support for red squirrel conservation continue to be high, with significant public involvement in the project’s work.

Introduction

Species background

The red squirrel (Sciurus vulgaris) is the only native squirrel species in Britain. It is smaller than the introduced grey squirrel (S. carolinensis), weighing approximately 300 g compared to the grey squirrel average of 570 g. Although identified in name by their colour, the fur of both species can vary markedly: red squirrels can be black to light brown on the back and white to cream on the front, whilst grey squirrels can be tinged with chestnut colours. Red squirrels do, however, have distinctive ear tufts in winter that can distinguish them from grey squirrels. More information on the physical characteristics and ecology of squirrels can be found in the SNH ‘Naturally Scottish’ publication Red Squirrels.

Once widespread across the UK, red squirrels are now largely restricted to the north of England, Northern Ireland and Scotland. Populations in Wales are scarce with only isolated populations remaining further south. Scotland is estimated to host about 75% of the UK population. Here the species has been lost from most of the Central Belt and is found primarily in the Scottish Borders, Dumfries and Galloway, Argyll, upland parts of Stirling, Perthshire and Angus, and in Grampian and the Highlands (Fig. 1).

Populations of red squirrels are thought to have undergone significant changes in the past.
Fig 1. Indicative distributions of red and grey squirrels in Scotland 2014. Source: SNH.
Following large-scale deforestation in the 18th century, they reportedly became extinct in some parts of Scotland. Animals were translocated from England and Scandinavia to reinforce, or reintroduce, populations in areas where they had declined or been lost.

Red squirrels are fully protected under the Wildlife & Countryside Act 1981. They were one of the first species to have a Species Action Plan under the UK Biodiversity Action Plan. Responsibility for these action plans was subsequently devolved to country groups in 2010. In Scotland, they receive additional protection under the Nature Conservation (Scotland) Act 2004 and the associated Scottish Biodiversity List. Red squirrels do not receive specific international protection as they are widespread and not currently threatened across much of their range from Europe to the east coast of Russia. There is, however, cause for concern due to the risks to continental populations from the spread of grey squirrels introduced to the Piedmont area of Italy in 1948.

Threats

The two main threats to the conservation of red squirrels in Scotland are the spread of grey squirrels and disease. Habitat fragmentation can make some areas less suitable for red squirrels, and increase the vulnerability of small populations. In the absence of competition from grey squirrels, national objectives for woodland expansion should benefit red squirrels.

Red squirrels in the south of Scotland are currently under threat from the squirrelpox virus. Research suggests that this was introduced to the UK with grey squirrels which have evolved with exposure to the disease and show no outward symptoms of infection (McInnes et al., 2009). In red squirrels the disease quickly results in severe skin lesions on the hands, face and groin, causing them to deteriorate in condition. It is invariably fatal. Recent work in south Scotland suggests that intensive grey squirrel control and appropriate habitat management can enable red squirrel populations to survive an outbreak. However, in the absence of co-ordinated grey squirrel control, red squirrel populations would not be expected to recover from such outbreaks.

Grey squirrels are a non-native species, having been introduced to Scotland from the USA and Canada in the late 19th century. A number of releases were carried out, in both England and Scotland, and their range has since expanded to cover much of southern and central Scotland. Grey squirrels can damage timber and other crops, and were included on the SAF list principally because of their invasive nature and the threats posed to native red squirrel populations.

The competitive replacement of red squirrels by greys has been the subject of extensive and ongoing research. There is evidence that the speed of replacement can be facilitated by the habitat, with only modest proportions of large-seeded broadleaved species within a woodland required to provide grey squirrels with a foothold and a competitive advantage over red squirrels. There is also evidence that the presence of squirrelpox virus greatly enhances the speed of replacement of red squirrels by greys and adds to the effects of competition.

Aims

The aims of the SAF plan for red squirrels reflected those of the Scottish Red Squirrel Action Plan 2006-11 (described below). These were to:

- Maintain populations of red squirrels across their current range in Scotland.
- Reduce the threat from grey squirrels.

Management Action

**Action implemented 2007-2102**

The work funded by SAF developed five main actions:

1. Implement strategic grey squirrel control measures to reduce spread of grey squirrels and associated squirrelpox virus.
2. Identify the priority sites for red squirrel conservation, based on a robust dataset of distribution and habitat management objectives.
3. Improve woodlands for red squirrels through appropriate forest planning and promotion of ‘red squirrel-friendly’ woodland management.
4. Support red squirrel conservation research, including methods of grey squirrel control,
potential for co-existence between red and grey populations, genetic variation in the Scottish population and effective data management.

5. Improve public awareness of red squirrel conservation and implement actions with public support.

**Saving Scotland’s Red Squirrels (SSRS)**

Strategic red squirrel conservation in Scotland has been approached collaboratively across public, private and non-governmental sectors since the establishment of the Scottish Squirrel Group in 1998. By 2005, nine local volunteer groups had been established across Scotland, four of whom received grant-aid from SNH to support Red Squirrel Conservation Officers. SNH had also been supporting a rolling programme of survey and monitoring under the Scottish Squirrel Survey from 2004 but, in 2005, recognised the value of developing a more cohesive network for red squirrel conservation action in Scotland. This proposal was formalised in the Red Squirrel Action Plan published in 2006, and SNH approached the Scottish Wildlife Trust (SWT) to take on a lead role in developing this further. Preparatory work began in August 2008.

The collaboration was formally consolidated with the launch of the ‘Saving Scotland’s Red Squirrels’ project (SSRS), a partnership of SNH, SWT, Scottish Land & Estates, and FCS, in 2009. This project became the principal means of funding and coordinating red squirrel conservation action throughout Scotland, although SAF-funded work in southern Scotland originally continued under the separate management of the ‘Red Squirrels in South Scotland’ (RSSS) partnership. Initially funded for three years and eight months (2008-12, including preparatory work), funding was extended by a further four years. The lead partner, SWT, secured matching funding to meet a project budget of just over £3 million covering 2008-16.

The remit of the SSRS project, initially focused in north and central Scotland, was extended to encompass south Scotland in 2012 when representatives from the RSSS project and the Red Squirrel Survival Trust joined the SSRS Steering Group. The project became the largest red squirrel conservation management project in the UK. The project is currently in Phase 3 (2014-16) with a mixture of funding from the public sector and SWT’s fundraising efforts.

The SAF-funded phase of the SSRS and RSSS projects (2008-12) had the aims of:

- Halting the spread of grey squirrels northwards of a protection line in central Scotland, and outwards from Aberdeen.
- Containing the spread of squirrelpox virus in south Scotland.
- Gathering evidence to establish if targeted grey squirrel control is a cost-effective and sustainable action for red squirrel conservation.

The project also sought to increase the involvement of private foresters and woodland owners in conservation efforts for red squirrels; and increase community engagement in red squirrel conservation.

The projects were serviced by a project manager, four project officers and up to ten dedicated Grey Squirrel Control Officers (GSCOs). Control work by the latter supplemented the work carried out by three controllers on the National Forest Estate in south Scotland, and by a network of landowners (assisted by project staff) supported by funding from the Scottish Rural Development Programme (SRDP), as well as via an SSRS co-ordinated trap loan scheme. By 2012, the project had a network of:

- 68 estates trapping under five-year SRDP contracts in north and central Scotland.
- 90 estates trapping under five-year SRDP contracts in south Scotland.
- 56 estates and over 200 individuals across both areas contributing control efforts through the trap loan scheme.

**Targeted species management**

SNH conducted a public consultation in 2009 to identify strategic priorities for control action to help inform funding decisions. This concluded that, whilst targeted grey squirrel control was needed to address the threat from grey squirrels in the short term, it was not a long-term solution and other actions, such as habitat management and the development of a vaccine against squirrelpox virus, were viewed as more sustainable approaches. Responses to the consultation also recommended that any changes in the distribution of grey squirrels should be monitored, particularly in Highland.

The SSRS project was informed by the results of the consultation, and a strategy launched in 2009 with specific geographic targets.
South Scotland

The specific action identified in the red squirrel implementation plan was to:

- Carry out a programme of grey squirrel control in south Scotland to monitor and address the spread of squirrelpox virus.

Grey squirrels were already widespread in south Scotland at the time of the SSRS launch. Work to contain grey squirrels in the area was already being carried out by a partnership of landowners and the Southern Uplands Partnership, acting as the ‘Red Squirrels in South Scotland’ project (RSSS). Progress was being made, but the RSSS project recognised the benefits of aligning with the methods, data protocols and strategic approach of the SSRS project. Hence the work in south Scotland was formally incorporated into the planning of the wider SSRS project in 2012.

SNH funding of the RSSS project supported employment in 2009–12 of one Project Officers and two GSCOs. Private grey squirrel control was initially funded under the Scottish Forestry Grant Scheme (SFSG), but this was superseded by the launch of the SRDP which provided support for landowners to control grey squirrels from 2009. By March 2012, 90 landowners were in receipt of five-year SRDP-funded contracts. These contracts

Fig 2. Red squirrel protection network across Scotland (2011/12). This shows areas with work being done by SSRS staff, SRDP-funded landowners and through trap loans.

Source: Scottish Wildlife Trust.
collaboratively provided 29,190 trap-days (i.e. the number of traps multiplied by the number of days on which traps were set across all landholdings) at a cost of more than £1m over the five-year period covered by the contractual agreements. Fig. 2 illustrates the coverage of grey squirrel control initiated by the project by 2013.

Given the relatively widespread distribution of grey squirrels in the region, work had initially sought to prevent the spread of grey squirrels infected with squirrelpox virus coming over the border from England. The first seropositive grey squirrel had, however, been detected in Scotland in June 2005, and subsequent control and analysis work by the projects mapped the slow spread of animals exposed to the virus.

Squirrelpox was initially detected in grey squirrels in the Liddel Water, followed by the Annan and Esk river valleys, and then at Thornhill in the Nith Valley in March 2008 and at Floors Castle, Kelso, in May 2008. The first Scottish red squirrel found infected with squirrelpox was recorded in September 2007 in the centre of the seropositive grey squirrel population near Lockerbie (McInnes et al., 2009). More red squirrels subsequently succumbed to the disease further north at Thornhill. Fig. 3 illustrates the known distribution of the virus in Scotland in 2012.

Work over the period 2012–14 indicated that it is likely to be extremely challenging to prevent the disease from spreading into parts of south Scotland that already have grey squirrel established. However, co-ordinated grey control may allow local populations to persist and recover. Habitats that are less suitable for grey squirrels may be those which are best able to maintain red squirrels, hence there is also justification for protecting populations in the large conifer-dominated forests in south Scotland, in particular the red squirrel strongholds of Fleet Basin and Eskdalemuir.

It is not possible at present to eradicate the virus, and although work has been ongoing to develop a vaccine to protect red squirrels, significant challenges remain as to how such a vaccine could be delivered to wild-living squirrels. Under these circumstances, the focus of subsequent project

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Fig 3. Distribution of grey squirrels with test results that indicate exposure to the squirrelpox virus in 2012. Key: red triangles – sero-positive grey squirrels; blue circles – sero-negative grey squirrels.

Source: Scottish Wildlife Trust.
control work has been to reduce the impact of squirrelpox virus on red squirrel populations, rather than containing the spread in areas where it is already established.

**North-east Scotland**

Grey squirrels were initially introduced to Aberdeen city in the 1960s and gradually spread out of the city along the courses of the Rivers Dee and Don. Red squirrel strongholds to the west of the city became threatened so action was planned at the outer limits of their known distribution to push the edge of grey squirrel range back along the river corridors towards the city. Control was also initiated in Aberdeen city to reduce the number of animals spreading out from parks and gardens, where they were numerous. The aim was to halt the decline of red squirrels in Aberdeenshire and demonstrate the effects of sustained, targeted and coordinated control on grey squirrel populations in the area. The longer-term aspiration was to eradicate this isolated population of grey squirrels from the city completely, but this was not viewed as feasible within the lifetime of the SAF-funded project.

Trapping results from north-east Scotland showed that the probability of grey squirrel capture declined steeply with increasing effort, indicating that control is having an effect on local grey squirrel abundance. In the north-east the probability of grey squirrel capture in the areas with the greatest control effort was seven times lower than in areas with lesser effort. The data do not support precise predictions of how long it might take to remove the populations from these areas, but indications are that this will require several more years in north-east Scotland (Tonkin et al., 2013). Although conducted over a relatively short time period, the results were sufficiently encouraging to demonstrate the value of maintaining grey squirrel control over a longer period of time. Correlating the reduction in grey squirrels with a significant increase in red squirrel abundance was more challenging for the project monitoring to detect in the timescales available, given annual fluctuations in squirrel populations. However there are numerous reports from the Aberdeen area of red squirrels returning to areas where they have not been seen for many years. These concur with the decline in grey squirrel numbers due to the project’s trapping activity.

The emphasis in the north-east was as much on urban as rural areas, with a greater focus on working in public spaces and with householders. Therefore the number of SRDP landowner contracts was lower than in other areas. However, by 2013, 11 landowners in the area were trapping under five-year SRDP contracts. This equated to 41,940 trap days over the five years and accounted for at least 600 grey squirrels being removed. This was supplemented by project-funded grey squirrel control (Table 1) and the participation of volunteers using the Trap Loan Scheme (including households allowing access to their gardens). The trap loan scheme in north-east Scotland made a larger contribution to the red squirrel protection network than elsewhere, with trap loans accounting for the removal of more than 900 grey squirrels in Aberdeen between 2011 and 2013.

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1. 2009 is the period August-December 2009, when the SSRS Project began trapping.
3. For 2009 and 2010, some of the trapping effort data are missing. Those included here represent only the capture data for which effort data were available.

Table 1. Trapping by SSRS staff in north-east Scotland, the Central Lowlands and south Scotland, showing the number of trap-days set per year and number of grey squirrels caught, in each area (from Tonkin et al., 2013).
Central Scotland

The consultation on grey squirrel control in 2009 helped to identify the northern limit of the known grey squirrel distribution in Scotland (with the exception of Aberdeen city). The resulting strategy set out a notional line, north of which was considered to be defendable from the advance of grey squirrels. Grey squirrel control was carried out along this line, from Angus to Argyll, and within an area approximately 15 km to the south of this. A network of control focused on natural ‘pinch points’ in the landscape, such as the A9 corridor and the Tarbet-Arrochar pass on the west of Loch Lomond.

Control of grey squirrels in the Central Lowlands aimed to prevent the increase and spread of grey squirrel populations rather than to eradicate them. Project staff initially identified locations for trapping, i.e. source populations from which grey squirrels could spread, subsequently handing over responsibility for sites to landowners funded by SRDP. The approach recognised, however, that the presence of several settlements in the area, such as Dunkeld, Callander and Blairgowrie, would necessitate the involvement of dedicated controllers to stem the spread. It would not be sufficient to rely solely on volunteer (SRDP-funded) efforts in the rural areas.

With several potential routes of dispersal through the Central Lowlands, the project also recognised the need for monitoring and reactive trapping north and west of the protection line.

The project tried to encourage landowners to sign up for SRDP-funded schemes in Tayside. This initially proved difficult as they were reluctant to get involved in the bureaucracy of the grant system but, following a few successful applicants, the scheme became very successful in this region, and in Argyll and the Trossachs. By 2013, 78 estates were supported by SRDP-funding. This equated to over 200,000 trap days, with the capture of more than 3,500 grey squirrels being reported via SRDP contracts from 2009 to 2012. This effort was in addition to the 30,000 trap days contributed by project staff in the Central Lowlands.

Identification of priority red squirrel sites

The identification of priority areas for red squirrels began prior to SAF, with publication of a preliminary assessment of priority woodland in north and central Scotland in 2005 (Poulsom et al., 2005). This was a desk-based study that provisionally identified 127 woodlands presenting suitable conditions for red squirrel habitation. FCS subsequently developed this into the red squirrel strongholds programme. Candidate stronghold sites were chosen using GIS data to identify large forested areas with the most positive characteristics for red squirrels. Comments and feedback were sought in a public consultation, and from that 19 stronghold sites across Scotland were selected. There are 18 strongholds on the mainland and one covering the whole of the Isle of Arran, almost 160,000 ha in total.

These large conifer and mixed forests span public and private land, and offer the chance for landowners (including the National Forest Estate) to work together across landscapes in a way that complements other red squirrel conservation work in Scotland.

The premise of the stronghold programme is that red squirrels are given a high priority when planning the future management of these forests. The defining aim for strongholds is to maintain a healthy, self-sustaining population of red squirrels through forest management. In other words, with suitable planning and management, strongholds should provide the red squirrel with a competitive advantage over the grey squirrel, and also act as red squirrel refuges in the event of grey squirrels expanding their range.

Development of squirrel-friendly woodland management

Long-term planning, and integrating red squirrel conservation measures with other forest management objectives, were recognised as the key to developing a healthy, self-sustaining population of red squirrels through woodland management. This was done mainly through the FCS strongholds programme, and guidance on how to manage forests to favour red squirrels was published in 2012 (FCS, 2012).

It is hoped that stronghold management can be delivered mainly by individual forest managers, applying new and updated forest plans. Site-specific management advice has been written for each stronghold. This will be published on the FCS website as a set of advice notes supported by digitised maps. The key management aim in each stronghold is to maintain or increase its carrying capacity - the broad-scale number of red squirrels that it can support through its variety and availability of food.
Research
The SAF implementation plan recognised the value of research in helping to inform difficult decisions, however, the focus of SAF was on practical action and whilst areas of research were initially identified and discussed, they were not substantially progressed under SAF.

Public awareness
Many actions initially identified under the SAF project required public support and involvement. This has been largely delivered by the SSRS through a number of local initiatives involving volunteers, landowners, estate workers, householders, schools and communities.

SSRS has engaged a large number of volunteers in its monitoring and trapping work, organised a roadshow of local meetings, attended public events with their mascot Sandy the Squirrel (Fig. 4) and managed an active Facebook site. Other local squirrel groups and initiatives have been active in a similar range of public engagement work.

The public voted the red squirrel as Scotland’s second favourite wild animal in the ‘Year of Natural Scotland’ Big 5 campaign. It is also consistently ranked highly as a species of public concern in the SNH ‘Nature Omnibus’ surveys, being the highest ranked species in 2014 (Granville and Mulholland, 2014). There is, therefore, continuing evidence of public support for conservation action for red squirrels.

Lessons Learnt, Further Work and Future Recommendations
The focus of SAF was on applied conservation action and the work funded for red squirrels through the programme delivered well against four of the five main actions identified.

The SAF Implementation Plan was based on work that was already underway through the Scottish Squirrel Group partnership. SAF funding did, however, enable this to be consolidated, and helped especially in coordinating many local projects through a unified management structure. Initially work across Scotland was administered separately in north/central Scotland and south Scotland. The funding framework combined cash and in-kind contributions and levered further SRDP funding and additional private sponsorship.

The SAF funding of SSRS meant that a comprehensive red squirrel protection network has been established, with monitoring protocols in place. This monitoring has enabled the evaluation of control efforts and their impact on grey squirrel populations. Due to the variable nature of squirrel populations, longer timescales are needed to refine estimates of the level of control effort that is likely to be required in the future, and to demonstrate sustained increases in red squirrel abundance or distributions. However, largely due to the knowledge gained through SSRS, there is now a greater public recognition of the benefits (and acceptability) of grey squirrel control, and appreciation that it may have a longer-term role to play in red squirrel conservation than previously recognised. The Scottish Strategy for Red Squirrel Conservation produced on behalf of the Scottish Squirrel Group was updated in 2015 and now reflects this change in emphasis.

Over the period 2008-15, red squirrel distribution was largely stable in all the SSRS project areas, but Ayrshire was identified as an area where grey squirrels continue to thrive at the expense of red squirrels. Elsewhere in south Scotland it has been challenging to quantify the effects of grey squirrel control, which has been reactive to new cases of the virus being found and hence not occurring at the same locations over time. However, red squirrels are still present in many of the areas that have experienced squirrelpox outbreaks and this has been attributed to the control efforts in these areas (White and Lurz, 2014).

Fig 4. Public awareness and education at a local event in Dunkeld.

Source: SSRS Facebook page.
The stronghold forest approach has allowed FCS expertise on woodland management to be enlisted and this provides a complementary and sustainable way to help red squirrel conservation. A methodology for monitoring red squirrels in strongholds is being developed, using a pilot study on four strongholds that are based largely on National Forest Estate land. FCS Conservancies will offer private landowners detailed advice on appropriate management and support that may be accessible under the second round of SRDP, 2014-2020.

The co-ordinated approach, which is a fundamental element of this project, has brought support and buy-in from politicians, landowners, volunteers and the wider public. Collaboration and consultation is expected to continue as the SSRS project, now in a third phase (2014-17), is looking towards future funding and delivery models. A key challenge is to ensure the sustainability of red squirrel conservation measures and this will require continuing public support for this work.

Phase 3 is seeking to gather more evidence of the benefits to red squirrels of grey squirrel control. It includes a continued programme of squirrelpox surveillance which is tracking the progress of the virus and raising awareness in local communities of the emergence of this threat to red squirrel populations in central Scotland.

Further Information

- [http://www.forestry.gov.uk/fr/INFD-8C8BLH](http://www.forestry.gov.uk/fr/INFD-8C8BLH) – Scottish Squirrel Group website.

Key Management Messages

- We have shown that a large collaborative partnership between government, public bodies, conservation charities, landowners and individuals, with a clear strategy and a dedicated co-ordination team, can work effectively for conservation benefit.
- The spread of squirrelpox virus poses a significant conservation threat to red squirrels because containment is much more difficult where grey squirrels are already established. However, the use of population modelling and disease surveillance during this project has highlighted that, by careful targeting of limited resources, grey squirrel control can still be beneficial in these circumstances.
- Gathering good quality data has been essential to support the case for continuing grey squirrel control with public funding.
- Making use of conservation strategies, rural incentives and forest planning processes allows a long-term view to be taken of the needs of red squirrels, and underlines the importance of long-term investment. The SSRS project will now further develop landowner and community engagement in order to move towards a more comprehensive sustainable delivery model.
References


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The SAF Partners

- Scottish Natural Heritage
- Scottish Wildlife Trust
- Forestry Commission Scotland
- Scottish Land & Estates
- Red Squirrel Survival Trust

As of 2015 the Royal Society for the Protection of Birds Scotland has joined the SSRS partnership.

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Scottish Wildcat

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Summary

• The Scottish wildcat was listed on the Species Action Framework (SAF) as a Species of Conservation Concern because of a decline in its distribution and abundance.

• Work under SAF initially sought to clarify the identity of the species and provide a practical description for field identification. This work drew together information on morphology and genetics into a single suite of characteristics accepted to be indicative of the Scottish wildcat.

• Work also focused on designing a method for survey and monitoring. Owing to the wildcat’s rarity and cryptic nature, remote camera-trapping was investigated rather than relying on direct observations. Further field trials resulted in a survey protocol which could be applied across geographic areas.

• Practical methods for wildcat conservation were developed and trialled in the field under the Cairngorms Wildcat Project. This comprised four main elements: raising awareness of wildcats and their conservation, responsible cat ownership, working with estates, and research and monitoring.

• SAF project funding contributed to important outcomes including: providing clarity on the species’ identity, practical survey methods, protocols for wildcat-friendly predator control, increased public awareness and a demonstration of how the benefits of responsible cat ownership could be promoted in wildcat areas.

• The Cairngorms Wildcat Project provided useful feedback on the resources required to manage widespread conservation measures for a rare and elusive species and directly contributed to the development and resourcing of ongoing action under Scottish Wildcat Action, a partnership project supported by the Scottish Government and Heritage Lottery Fund.

• Follow up to SAF is now being taken forward as a wide-ranging package of action through the Scottish Wildcat Conservation Action Plan (SWCAP) (2013).

Introduction

The Scottish wildcat (Felis silvestris) is the only native member of the Felidae, the cat family, still to be found in the wild in Britain. It is one of our rarest, and most elusive, mammals (Fig.1).

It belongs to the European wildcat sub-species, which is one of six wildcat sub-species that were once widely distributed across Europe, Asia and Africa. Heavily persecuted, the Scottish wildcat population declined markedly in both number and range. European wildcats have also experienced declines in other parts of their range. Wildcats became extinct in Austria and the Netherlands in the first half of the 20th century (though with recent reports of their return to Austria from Italy in 2008), and declined in the Czech and Slovak Republics. They are now confined to three major areas of the former Soviet Union: the Carpathian Mountains of the Ukraine, the Kodry region of Moldova and the Caucasus mountain region between the Black and Caspian seas. Elsewhere in Europe, isolated populations are limited to the Iberian Peninsula, Italy, north-east France-Luxembourg-Belgium, north-west Germany, eastern central Germany and the Balkans (Yamaguchi et al., 2015).

The wildcat population had already declined in Britain by the early 1800s and was lost from England and Wales by 1862. The decline in
Scotland continued into the 20th century and the range was ultimately confined to the north-west by the 1920s. There was an expansion in range over the following 20 years, possibly a reflection of increased numbers, but the range has been considered to be stable since the 1940s.

The current status of the Scottish wildcat is unclear. A questionnaire survey in 1983-87 suggested that the species was restricted to an area north of the Central Belt, with the main populations found to occur in north-east Scotland, Easter Ross, north-east Inverness-shire, Strathspey, east Perthshire and parts of Argyll (Easterbee et al., 1991). A subsequent survey in 2006-08 sought to repeat the method and concluded that the wildcat appeared to be stable in its historic locations in the north and east of Scotland, with localised populations persisting around Ardnamurchan and Morvern (Davis and Gray, 2010). Its fate elsewhere was less clear, however, with information obtained often being insufficient to distinguish wildcats from feral domestic cats.

Scottish wildcats are generally found on the edge of woodland, or in scrub at the margins of rough grazing and moorland. Animals living in the east and west of Scotland, however, appear to show some differences in preference: those in the east prefer marginal agricultural areas with moorland, grassland and woodlands; whilst those in the west favour rough grazing and moorland with limited pastures. Animals in both areas seem to avoid high mountains, exposed coasts, and fertile lowlands with intensive agriculture.

Geographic differences also figure in their diet. Rabbits constitute up to 70% of the diet of animals in the east, compared to a preponderance of voles and mice in the diet of animals from the west (where rabbits account for only 34% of the diet). Wildcats hunt by both day and night, although they can be inactive for up to 24 hours in the winter if the weather is inclement.

More details on the ecology and behaviour of this important species are available on the SNH website and in the SNH Naturally Scottish – wildcats booklet.

The Scottish wildcat is listed for strict protection under Annex IV of the EC Habitats Directive, making it a European Protected Species under UK law through the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended). The species faces several threats including hybridisation with feral cats, incidental harm as a result of predator control, exposure to new diseases (primarily those found in domestic cats), habitat fragmentation and habitat degradation. Urgent action is required to address the decline in distribution and abundance of the Scottish wildcat and it was for this reason that it was included on the SAF list as a species of conservation concern.

One of the main problems facing wildcat conservation has been the lack of a definite taxonomic description. The challenges this presents were exemplified in 1990 when an expert witness could not state in court ‘beyond reasonable doubt’ that three cats which had been killed were Scottish wildcats. This statement cast doubt on the definition of a wildcat and the ramifications of this have undermined much conservation action in the intervening years. Work under SAF therefore sought to address this uncertainty and establish practical conservation management action.

This work has underpinned the development of the 2013 Scottish Wildcat Conservation Action Plan and its ensuing implementation under the banner of Scottish Wildcat Action, a partnership project supported by the Scottish Government and Heritage Lottery Fund that unites leading experts from over 20 key organisations. This work is also referenced as an update to wildcat conservation action since SAF came to an end.

Aims

Objectives for 2007-2012

Five actions were identified at the outset of the SAF project, to:

- Provide a robust dataset from which to clarify the distribution (and abundance) of the Scottish wildcat.
- Identify potential wildcat stronghold areas for conservation action.
- Improve guidance on methods to improve habitat management in potential wildcat areas to encourage (colonisation by) a sustainable population.
- Initiate a programme of wildcat conservation measures to reduce the threat from hybridisation with feral/domestic cats.
- Raise awareness of the status of the Scottish wildcat and establish the appropriate partnerships to support co-ordinated management action for its conservation.
Management Action

Summary of the main actions carried out

The work funded by SAF developed three objectives:

- **Identification of the Scottish wildcat** – Research drew on existing information and specimens available, to examine the correspondence between the pelage (coat) characteristics and genetics of the wildcat. This work informed development of a practical guide for identifying wildcats.

- **Development of survey field methods** – The wildcat is elusive and difficult to survey. This research used camera-traps to photograph wildcats in the wild and develop a detailed survey protocol.

- **Development of a project to secure the future of the wildcat in the Cairngorms area** – A three-year partnership project was established within the Cairngorms National Park to trial management which reduced the risks to the local wildcat population.

**Identification of the Scottish wildcat**

Following the ruling of the 1990 court case in Stonehaven, any taxonomic identification of the Scottish wildcat was open to challenge and it became more difficult to enforce the legal protection for the species. This undermined attempts to carry out conservation action for the species. One of the fundamental priorities for the SAF project was, therefore, to establish a suite of criteria by which a Scottish wildcat could be recognised in the field.

Prevailing research on the subject had used either pelage characteristics (Kitchener et al., 2005) or genetic research (Driscoll et al., 2007) to describe the species. In 2008, work was commissioned to draw these together to examine the relationship between the genetics and morphology of the Scottish wildcat (Kilshaw et al., 2010). The study tested 330 cat pelages against the criteria developed by Kitchener et al. (2005) as well as assessing 208 individuals for their skull characteristics. Genetic analysis was conducted on 245 of these individuals (microsatellite analysis or mDNA work) and the results cross-referred to determine any correlations.

The research concluded that at least 70% of the specimens gathered from wild-living populations and held in museum collections were hybrids of wildcats crossed with domestic cats, or were domestic cats. It identified three distinct groups of cats based on their pelage markings and found that these groupings could be largely distinguished by their genetic characteristics. Whilst the correlations were not perfect, the research confirmed that pelage characteristics, as set out by Kitchener et al. (2005), were sufficiently accurate to identify individuals that are genetically different from domestic cats.

This work was crucial to underpin development of field survey methods and guidance for land managers on how to protect the species during legitimate land management activities.

Further to this SAF work, as part of a ‘Knowledge Exchange’ initiative, conservation geneticists carried out a review of wildcat genetic studies and implications for management (Neaves and Hollingsworth, 2013). This review supported earlier conclusions that pelage is a useful indicator of wildcat ancestry and highlighted some of the challenges of managing for genetic purity or for morphology and/or ecological function. With the advance of new genetic techniques, the focus has shifted to studies involving Single Nucleotide Polymorphisms (SNPs) - individual marker points in the DNA sequence that are common to reference groups (putative wildcats and domestic cats) and from which inferences can be made about the make-up of individuals. Based on genetic studies from continental European wildcats, a set of SNP markers that are thought to apply to Scottish wildcats have been selected and refined (Senn and Ogden, 2015). A methodology that combines genetic and morphological assessment has been developed to select individuals for conservation breeding as part of Scottish Wildcat Action.

Identification of wildcats in the field under Scottish Wildcat Action will take a pragmatic approach and will be based on appearance and scoring of pelage characteristics.

**Field survey methods**

Following the work on identification of wildcats from pelage markings, it was important to develop an efficient and effective survey method by which to assess the status of the species in the wild. Scottish wildcats are a cryptic species, and difficult to observe directly, so a study was set up to investigate whether camera-trapping was a feasible
method for monitoring the population. The study sought to confirm camera-traps as a useful resource for wildcat monitoring and, ultimately, to define the criteria for their use.

The results of the study (Kilshaw and Macdonald, 2011) were very encouraging and camera-traps did capture images of wildcats in areas where they were known to occur from previous sightings. Traps that used bait had increased capture rates and obtained multiple images, while those that used ‘Valerian lures’ did not attract wildcats in this study. No feral cats were photographed and gamekeepers did not report seeing ‘wild-living’ cats on the estate during the trapping period, highlighting the cryptic nature of wildcats. Photographs of wildcats were of sufficient quality to enable individuals to be recognised by their pelage markings. The ability to identify individual animals from photographs also meant that the method could be used to provide estimates of numbers or population densities and, thus, as a tool for monitoring the species. The work produced a practical protocol for camera-trap surveys with the recommendation that further work to refine this could improve its utility as a tool for monitoring wildcat populations.

Further to this study, and the use of these methods in the survey and scoping of wildcat priority areas (Littlewood et al. 2014), a simulation of camera-trap survey design has helped to understand the limitations of these methods in terms of statistical power. Survey designs that should be capable of producing estimates of the number of individual cats observed, and from this population densities, are achievable with the investment of significant resources. However, given the very low capture/detection rates experienced, and wide confidence intervals in the density estimates derived, even the most intensive survey designs are likely to struggle to detect population trends with confidence (Newey et al., 2015).

Development of a project to secure the future of the wildcat in the Cairngorms National Park

As the 2006-08 wildcat survey (Davis and Gray, 2010) confirmed that wildcats still occupy their historic range of north and east Scotland, the Cairngorms National Park (CNP) was considered a good place to test practical conservation action for the species. The Cairngorms Wildcat Project (CWP), initiated in 2008, was a partnership between the Cairngorms National Park Authority (CNPA), Scottish Natural Heritage (SNH), The Royal Zoological Society of Scotland (RZSS), the Scottish Gamekeepers Association (SGA) and Forestry Commission Scotland (FCS). It ran until March 2012 and was largely funded by SNH under SAF, with additional funds generated through the Highland Tiger appeal administered by the RZSS. A Project Manager was employed, based at the CNPA.

The CWP aims were to:

- Secure the future of the Scottish wildcat within the CNP, leading to further action across a wider area of Scotland.
- Raise awareness of the plight of the Scottish wildcat.
- Promote public support for wildcat conservation measures.
- Work with land managers in the CNP to ensure that the population of Scottish wildcats benefit from existing feral cat control activities.
- Set in place sustainable feral cat management, with the support and co-operation of landowners, such that this will become self-sustaining beyond the life of the project.
- Carry out research and monitoring to develop a greater understanding of Scottish wildcat conservation status, ecology, genetics and epidemiology within the context of the project.
- Engage the support of the local community for responsible domestic cat ownership, including participation in voluntary neutering and vaccination schemes.
- Provide an efficient and effective programme of activities which could be applied for the benefit of Scottish wildcats across a wider geographic area of Scotland.
- Capitalise on the charismatic nature of the Scottish wildcat in the CNP to nurture an ethos of collaboration and ownership in the CWP across a wide spectrum of interest groups and individuals.

The CWP was initiated at a conference, entitled ‘Practical wildcat conservation in the Cairngorms National Park’, in April 2008. This event was attended by around 100 delegates from a wide variety of sectors and identified options for conservation management as well as helping to raise awareness of wildcats and their plight. It was clear from the conference that many people wanted to see a practical trial of methods rather than a
research-focused project. This shaped subsequent development of the CWP.

Project management focused on four main categories:

- Raising awareness of wildcats and their conservation.
- Responsible cat ownership.
- Working with estates and land management.
- Research and monitoring.

**Raising awareness of wildcats and their conservation**

From the outset it was agreed that raising awareness of the wildcat and its plight was critical to the success of any wildcat conservation project. Two key groups that the CWP wanted to influence were domestic cat owners and gamekeepers.

The CWP chose a strong brand to help focus the Project messages. The ‘Highland Tiger’ brand provided a link to conservation efforts directed at high-profile big cats in other countries and the work required to sustain our own last remaining native felid species. A number of awareness-raising materials were developed using this brand, including a dedicated website, social media, postcards, and a short DVD, which was distributed to people in a position to reach a wider audience, such as schools and societies. The CWP also enjoyed positive and widespread coverage in all media, and gave a total of 52 presentations in the Cairngorm area to a combined audience of over 2,000 people.

In addition to the broad public awareness-raising work, the CWP targeted specific conservation messages at key sectors, such as local cat-welfare groups, vets, farmers and gamekeepers, through the use of printed media or face-to-face presentations and workshops.

**Responsible cat ownership**

Domestic cats pose a serious conservation threat to Scottish wildcats through introgressive hybridisation and, potentially, disease transmission (Macdonald et al., 2004). They may in some circumstances also compete with wildcats for resources such as territory, food and mates. They are fairly widespread in the CNP, particularly around settlements and farms.

To reduce the threats posed by domestic cats, the CWP delivered a series of actions to encourage neutering and vaccination of domestic cats. Neutering removes the domestic cat’s capacity to hybridise with wildcats but also (potentially) limits the growth of the domestic cat population, reducing further the risk of competition and disease transmission. Vaccination of pet cats and screening feral cats for disease also aimed to reduce the likelihood of fatal diseases being spread to wildcats.

Responsible cat ownership involved two important partners: the local veterinary community and Cats Protection, the UK’s largest cat welfare organisation. The majority of unneutered and unvaccinated cats in the National Park were thought likely to be farm cats, and vets agreed to be unofficial ambassadors for the CWP during their dealings with farming clients, making enquiries about cats on farms and advocating neutering where possible. They also agreed to provide data on neutering and vaccination so as to help identify trends and patterns over time.

Cats Protection has a network of volunteer branches across Scotland and their expertise, policies and resources were important to help achieve the project objectives. Volunteers were trained in feral cat ‘trap-neuter-release’ (TNR) methods and the coverage provided by the Cats Protection network contributed significantly in important areas for the CWP, including a significant proportion of the eastern side of the National Park. Over 20 new volunteers were recruited, most of whom were attracted by the wildcat conservation angle. In addition two new branches were instigated, increasing the coverage of volunteers carrying out TNR in the National Park.

The CWP also produced a leaflet promoting the need for responsible cat ownership (Fig. 2). This was endorsed by all local veterinary practices and the TV vet, Joe Inglis. The leaflet outlined the reasons why neutering domestic cats is important for both cat welfare and wildcat conservation, as well as providing contact details of local vets and an explanation of the support that Cats Protection could provide. The leaflet was made widely available across the National Park to vets, Cats Protection volunteers, and National Park rangers, as well as at various local events, visitor centres, and local shops and supermarkets selling cat food.
Working with estates

The CWP worked with the gamekeeping community to establish a practical protocol for predator control activities that minimised the risks of harming wildcats. Five estates participated in the CWP by adopting the protocol and reporting on their feral cat control activities and any wildcat sightings.

As part of their game-bird management, estates routinely and legally control mammalian and avian predators, including foxes, corvids (except ravens), weasels, stoats and mink. Foxes are often controlled using lamping techniques, which employ a powerful spot-lamp at night to detect fox ‘eye-shine’, and feral cats are often shot during this work. The colour and size of the eye-shine can be used to discriminate between species, but not between wildcats and feral cats. So if feral cats are shot on the basis of a cat body-shape or cat eye-shine, there is a risk of a wildcat being shot inadvertently.

Trapping, using baited live-traps or snares, reduces the risks of errors as animals are caught alive. These traps must, by law, be checked at least once every 24 hours, and both trap types should allow non-target species to be released unharmed. With spotlighting, snaring and cage-trapping, the safety of an endangered and legally protected species is heavily dependent on the judgement of the gamekeeper. It was important, therefore, to ensure that sufficient information was available to support gamekeepers as wildcats can potentially be caught as an incidental result of legal predator control.

In order to facilitate communication, the Scottish Gamekeepers Association (SGA) was invited to be a partner in the project and provided an important conduit to members, promoting clear and consistent messages about wildcat conservation and responsible predator control.

A workshop with gamekeepers helped to design a draft protocol to aid field identification of wildcats (Fig. 3) and help encourage wildcat-friendly predator control activities. The protocol encouraged gamekeepers, when engaged in routine feral cat control work, not to shoot if there was any doubt about a cat’s identity. To improve confidence in wildcat identification, the CWP also provided laminated identification cards with a diagram of coat markings based on the Kitchener et al. (2005) description. These were intended to be small and durable enough to be carried in a trouser pocket or glove compartment, and were distributed widely to Cats Protection volunteers as well as gamekeepers, including those on the five estates.
Wherever possible, gamekeepers were encouraged to use live cage traps for feral cat control rather than rely on night-time shooting or snaring. The Project’s protocol encouraged the estate to re-home, via Cats Protection, any errant pets caught in cage traps, while feral cats were neutered via Cats Protection or humanely dispatched by estate staff.

Once the protocol had been disseminated and promoted, the Project Manager met regularly with staff from the estates to gather information. A record was maintained of the number of gamekeeping staff employed, the amount of effort invested in cage-trapping and night shooting, and the number of feral cats caught or shot. As many cat records as possible were collated from the estates, including sightings by staff and members of the public, and photos, including from opportunistic camera-trapping, as well as any road traffic carcases available.

Research and monitoring

Research and monitoring under the CWP focussed mainly on the use of camera-trapping to survey and monitor the wildcats. An intensive camera-trap study was initiated, and repeated, on the five target estates with three aims:

1. Assess the numbers of wildcats, hybrid cats and domestic cats.
2. Assess changes in the numbers of cats during the project.
3. Investigate the ecology of wildcats, hybrid cats and domestic cats to inform future management of cats for wildcat conservation.

Twenty pairs of camera-traps (Cuddeback Capture® or Capture® IRs) were set out in a grid of 4 x 5 pairs on each of the five participating estates. The survey protocol followed that of Kilshaw and Macdonald (2011), and cameras were placed preferentially (but not exclusively) under cover near open habitat at locations showing one or more of the following features (Scott et al., 1993; Daniels et al., 2001; Lozano et al., 2003; Ballesteros-Duperón, 2005; Potočnik et al., 2005; Theil, 2005):

- On or near paths or game-trails.
- Along linear features such as drystane dykes, stock fences and riparian belts.
- At bottlenecks for animal movement such as holes in otherwise animal-proof fencing (such as deer-fence with narrow-gauge mesh).

Cameras were set in pairs to minimise data loss from camera failure and to maximise the likelihood of photographing both sides of visiting cats. Camera pairs (stations) were baited using a combination of lures including feathers, scent (Hawbaker’s Wildcat Lures Nos. 1 and 2) and meat (chicken leg, pheasant or deer offal). Scent and meat lures were refreshed at the beginning of weeks 3, 5 and 7 although no meat bait was used on two of the estates. Surveys lasted up to 84 days.

Individual cats were identified based on pelage markings, thus the location, date, time and identity was known for each cat photographed (or ‘captured’).

The first 60 days of each survey were used to assess population change and density (Kilshaw and Macdonald, 2011). The low numbers of wildcats captured, combined with only two years data, precluded the use of complex capture-mark-recapture (CMR) models in most cases. Changes in cat
populations between the two years were assessed using a t-test, paired by estate, on the number of cats of each group (wild, hybrid, domestic) captured, i.e. the minimum number alive (MNA).

Outside the intensive camera-trapping periods, estate staff assisted with opportunistic camera-trapping. In addition, the CWP loaned out cameras to key individuals and organisations for smaller-scale opportunistic camera-trapping around the National Park. Cameras were looked after by National Park rangers or by staff from partner organisations, local conservation groups or wildlife enthusiasts given best practice information developed during the intensive camera-trapping sessions on the estates. Several cat photos were taken at different sites across the National Park, thus adding to the understanding of wildcat distribution and behaviour.

Records of sightings and road-kill carcases can also provide a useful source of data about the potential distribution of wildcats. Members of the public were encouraged to report sightings via a form on a website. Records were classified as ‘possible wildcat’, ‘probable hybrid’ and ‘feral cat’ taking account of the evidence available to substantiate the record (e.g. photograph or carcase) and the information provided. All records were subsequently logged on a Geographic Information System (GIS) and passed to the North East Scotland Biological Records Centre (NESBReC) to be forwarded for public access through the National Biodiversity Network (NBN).

The public were encouraged to report road-kill carcases to the CWP and, where possible, these were stored in freezers. The carcases of some of the tabby-marked cats that were shot on the estates were also retained in freezers for analysis. In total, 56 carcases of tabby-marked cats were retrieved via the CWP and sent to the National Museums of Scotland (NMS) in Edinburgh for analysis of pelage and skull morphometrics, to determine their taxonomic status.

Lessons Learnt, Further Work and Future Recommendations

The SAF wildcat project addressed three fundamental elements of a successful wildcat conservation programme: clarifying the identity of the Scottish wildcat, developing methods for survey and monitoring and testing practical conservation methods in situ.

- **Taxonomy** – the lack of a clear identity for the Scottish wildcat had undermined progress on conservation of the species for about 20 years. Whilst work was progressing on a practical field description, drawing together knowledge of morphology and genetics provided a catalyst for further progress. The provision of ‘strict’ and ‘relaxed’ descriptions of the wildcat, aligned to genetic information, gave the confidence to develop methods for field survey as the basis for further conservation action. These identification criteria have subsequently been refined for application in different applied conservation scenarios, for example to determine which cats are appropriate for neutering and for conservation breeding.

- **Survey methods** – SAF-funded work demonstrated the value of camera-traps to survey and monitor the Scottish wildcat. The method was trialled and developed further as part of the Cairngorm Wildcat Project (CWP) and provides a legacy protocol which can be used elsewhere. In Cairngorm this, combined with the recovering of cat carcases, indicated that feral cats and hybrids live in the same areas as wildcats, but are more numerous and widespread than previously thought. It clearly demonstrated the active risk to wildcats from hybridisation and disease transmission.

- **Public engagement** – the CWP recognised early the benefits of good public engagement and adopted a suite of methods to promote this. The success of this approach was demonstrated by a notable increase in awareness and involvement in the project, including financial donations to the Highland Tiger fund.

- **Working with estates** – the project also recognised the important role played by estate managers in conserving the wildcat. The involvement of the SGA clearly opened up opportunities to disseminate the project
Key Management Messages

- One of the major successes of the CWP is the effective partnerships formed between conservation and land management interests. The SWCAP partnership now embraces more than 20 partner organisations. Such a diverse partnership brings challenges, but also great strengths, with so many individuals and organisations committed to the same cause.

- Having a common understanding of wildcat identification criteria, despite the taxonomic complexities, is probably the foremost factor that has allowed conservation action for the Scottish wildcat to progress. Having a sound scientific basis is essential for making sound management decisions. Refinement of management criteria will continue as our knowledge of the status of wild-living populations improves.

- Conservation action sometimes needs pragmatic decisions. CWP trialled approaches in the field that have been adopted by Scottish Wildcat Action, and which recognise that we are trying to protect a group of cats that look like wildcats, but may not all be genetically pure wildcats.

- Trials of practical conservation management are essential as a building block for learning. Many of the lessons from CWP have been extended and incorporated into a national wildcat conservation action plan.

messages and encouraged gamekeepers to adopt wildcat-friendly management regimes. The protocol for wildcat-friendly estate management has also had a legacy, having been adopted in the work of Scottish Wildcat Action in wildcat priority areas. This work also contributed to the development of the Wildcat Friendly Predator Control option now available through the Scottish Rural Development Programme in wildcat priority areas to assist land managers in their efforts to take a more precautionary approach.

- Responsible cat ownership – Direct engagement with the local veterinary surgeries and Cats Protection branches helped to promote neutering and vaccination of domestic and feral cats. Whilst it was difficult to gauge if any increase in the numbers of cats being neutered and vaccinated could be attributed to the project, the number and distribution of Cats Protection volunteers clearly widened opportunities to reduce the risks in the CNP.

- Resourcing – Roll-out of the full package of measures in the CWP required a dedicated staff resource. The efficacy of some of the measures trialled, for example the promotion and co-ordination of TNR, has been reviewed and greater prominence has been given to volunteer co-ordination under Scottish Wildcat Action. The Scottish Wildcat Action work in priority areas has a dedicated staff of six, a project manager, a communications co-ordinator and four project officers covering the six priority areas. Working with local communities, land managers, vets and volunteers is a large part of the project to ensure there is an enduring impact. Much of the programme of Scottish Wildcat Action work draws on earlier experience from CWP. Hence there is a strong legacy of SAF in ongoing wildcat conservation action.

Of the original SAF aims, significant progress has been made with clarifying wildcat identification and in raising awareness of the threats to wildcats. More limited progress was made with developing our understanding of distributions and abundance, but tools have been developed that will assist this process in the future. The emphasis on some of the original SAF aims over others also largely reflected stakeholder views, which clearly favoured a trial of practical conservation measures. This work took precedence over developing habitat management recommendations and the identification of stronghold areas, but these outstanding aims have become part of the Scottish Wildcat Conservation Action Plan (SWCAP), with priority areas being identified in 2014 (Littlewood et al., 2014).
Further Information


References


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The SAF Partners

- Scottish Natural Heritage
- Cairngorms National Park Authority
- Royal Zoological Society of Scotland
- Scottish Gamekeepers Association
- Forestry Commission Scotland
Species management in Scotland 2007–2012

Water Vole

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Summary

• The water vole (Arvicola amphibius) was formerly widespread and abundant throughout many river systems in Scotland. It is now patchily distributed, with most surviving populations in headwaters, away from the downstream areas preferred by non-native American mink (Neovison vison).

• This chapter focuses on the Trossachs Water Vole Reintroduction Project, although this comprises just one element of the overall Species Action Framework (SAF) funded work for water voles. Because of the close negative predator-prey association between invasive American mink and water voles, much of the experience detailed in the American mink chapter of this handbook also relates directly to water vole conservation.

• The project demonstrates how extensive re-structuring within a large commercial conifer forest to create productive wetland habitat can be applied to form the basis of a water vole reintroduction programme.

• It began in 2008 using captive-bred offspring from water voles captured at a development site in Lanarkshire. Releases took place from 2008 to 2011 accompanied by a monitoring programme and the establishment of a mink-raft network to detect and remove mink.

• With continuing mink control, the re-established vole colonies are thriving and spreading out into new areas up to 12 km from the release sites. Thousands of hours of volunteer time (involving around 120 volunteers) have contributed to surveying and monitoring water voles and controlling mink.

• The need for continuing mink control was acknowledged at the outset and takes place annually on Forest Enterprise Scotland (FES) land and the surrounding area. As water voles show signs of re-colonising beyond the FES boundary, the need for larger-scale strategic mink control is becoming more evident. Ultimately, further range expansion by water voles is dependent on expanding the mink control effort into surrounding areas, involving key stakeholders such as the local fisheries trusts/fishery management organisations and other land managers.

Introduction

Species background

The water vole was formerly one of our most familiar and abundant riverside mammals. It is the largest of the British voles and, although still reasonably widespread, it is now absent or scarce from many areas where it was once common. Most Scottish populations are now to be found in the uplands.

Why was this species on the SAF list?

The water vole satisfied criterion 1a of the SAF as a species for conservation action (Scottish Natural Heritage, 2007).

It had suffered a significant decline, especially in the 1990s. Management action was needed to address threats from habitat loss and, in particular, from predation by American mink, an invasive non-native species. The water vole is a high profile species and highlights the damaging effects of invasive non-native species. Management targeted at water voles, such as mink eradication projects, benefits the wider ecosystem in which the vole lives (American mink is also on the Species Action List and actions relating to this species cross-link to the water vole).

It was identified as a UK Biodiversity Action Plan (UKBAP) Priority Species and is included on the Scottish Biodiversity List. In Scotland, the places of shelter or protection of the water vole are protected under the Wildlife and Countryside Act 1981 (as amended), but not the animals themselves. However this level of protection is under review and full protection has been proposed.

Habitat, distribution and abundance

In lowland areas, water voles occur in small slow-flowing or static burns, small backwaters, canals, ditch systems and overgrown field drains, and sometimes in intensively-farmed and urban areas. Such watercourses are typically less than 3 m wide and 1 m deep and do not show extreme fluctuations in water level. Water voles prefer sites with easily excavated soil and a steeply sloping bank profile into which they can burrow. The best sites support a continuous swathe of tall herbaceous riparian vegetation. Sites excessively shaded by shrubs or trees are avoided. In the
uplands, areas with a thick layer of peat on flat or gently sloping ground are preferred (Strachan et al., 2011).

The species is widely distributed elsewhere in Britain, but is now very localised owing to numerous local extinctions and is largely restricted to smaller watercourses and headwaters. It is also widespread in continental Europe where it commonly occurs underground well away from open water. This ‘fossorial’ form also occurs in Scotland on the Reisa Islands in the Sound of Jura (see American mink chapter of this handbook) and at various locations in Greater Glasgow.

General ecology

Water voles live in loose colonies within ‘metapopulations’ (Strachan et al., 2011; Capreolus Wildlife Consultancy, 2005). Each female vole defends a linear territory of 30–50 m, while males occupy home ranges of 60–300 m, often overlapping the territories of several females. Both sexes use their droppings in conjunction with their scent glands to mark these areas (Strachan et al., 2011).

Scottish water voles are genetically distinct from those further south. The voles that colonized England and Wales following the last ice age originated from south-east Europe, whereas Scotland’s voles are descended from migrants from northern Iberia (Piertney et al., 2005).

History of decline, contributory factors and current threats

The water vole is widely acknowledged to be one of our most threatened native mammals, having undergone a dramatic decline, particularly during the latter part of the 20th century. The total UK population was reduced by 88% between 1989 and 1996. Factors causing loss or decline include habitat degradation and fragmentation, combined with predation by American mink. The decline is attributed largely to the spread of mink across the country (Macdonald and Strachan, 1999).

Aims

Aims and objectives for 2007-2012

The partners involved in the SAF work, and other conservation organisations, already carry out a range of work that aims to benefit water voles in various ways, such as ensuring proposed developments do not affect the integrity of water vole populations, initiating systematic water vole surveys in areas of poor coverage and targeting key river catchments for habitat management. For the purposes of SAF, however, the focus was on addressing two main aims and objectives:

- Identify sites that are suitable for re-establishing populations (where natural recolonisation is very unlikely).
- Employ mink control as a conservation tool to protect important water vole populations.

It was recognised that mink control may also include related actions to prevent mink colonisation, such as habitat management to reduce denning opportunities, and targeted control of rabbits, which can provide an important prey base for sustaining mink in an area.

Management Action

Action for water voles undertaken as part of SAF focused specifically on:

- A landscape-scale strategic mink control programme (the Scottish Mink Initiative (SMI)), and targeted mink control on the Reisa Islands. The American mink chapter of this handbook gives details of these projects.
- A reintroduction programme – the Trossachs Water Vole Project, described in more detail below.

There were two important predecessors of the SMI that together developed the community-based approach to mink control, and focused primarily on water vole conservation in north-east Scotland for several years. They are not discussed further here although some background is given in the American mink chapter of this handbook. Bryce et al. (2011) also reviewed the experience and key findings of the larger of these, the Cairngorms Water Vole Conservation Project, which ran from 2006 to 2009.
Aims of the reintroduction project

The Trossachs Water Vole Reintroduction Project began in 2008 with the following aims:

1. Define the conditions and procedures required to re-establish water vole populations in water catchments where they have recently become extinct, and inform future reintroduction projects.
2. Successfully re-establish water voles in an upper water-catchment including newly created and restored habitats in Cowal & Trossachs Forest District.
3. Raise public awareness of water vole conservation, this reintroduction project and the contribution of partner organisations, through interpretation and education.

Partnership working and resourcing

A partnership steering group was formed and the first Project Officer was employed by FES in May 2009 to help with the planning, implementation and monitoring of the water vole reintroduction (following the first releases in 2008). The Trossachs Water Vole Project partnership organisations included FES, the Royal Zoological Society of Scotland (RZSS), Loch Lomond & the Trossachs National Park Authority (LLTNPA) and Scottish Natural Heritage (SNH). The project partnership employed the officer, with project funds held and managed by the RZSS. The post was initially funded by SNH through the SAF project and then latterly through joint funding from FES, LLTNPA and RZSS when the officer’s time was split equally between the water vole project and other RZSS work. The post was originally required to operate for seven months over the periods April–October 2009 and April–October 2010, i.e. on a part-time, flexible and seasonal basis. Then, because of changes in the monitoring plan, it was decided to extend these terms to include one day per week between November and March 2010 inclusive. The partner organisations contributed as follows:

- FES staff were responsible for recruiting and managing the Project Officer, training volunteers, undertaking the water vole releases, trapping, surveying and control of mink, part-funding the Project Officer post and continuing habitat restoration.
- LLTNPA staff contributed significantly to the survey effort and assisted with the water vole releases, co-ordinated volunteers and assisted with the mink monitoring. They also contributed to the steering group, and helped to fund the project in 2009.
- RZSS employed the Project Officer from 2010 to 2013, worked with the Project Officer to develop interpretation for the project and assisted with the releases and trapping. They also funded the captive breeding programme for part of this period.
- SNH provided financial support, advice and expertise.
- The Derek Gow Consultancy housed and bred the water voles, assisted with releases, and provided advice on releasing and trapping.

The project relied heavily on the contributions of volunteers. Each year since 2008, LLTNPA volunteers and others have participated in an annual training day in April, focusing on the survey methods to be used during the monitoring. Around 120 volunteers have taken part in surveys. Their efforts have enabled over 200 km of waterway to be surveyed as part of the project. FES volunteers have also assisted greatly towards the mink monitoring, water vole releases and trapping.

Planning

The origins of this project lie in discussions between FES and the Derek Gow Consultancy in 2006. The latter was advising on the water vole mitigation plan for the re-development of a landfill site and associated habitats, at Kilgarth, North Lanarkshire, into a rail freight depot. Additional water voles captured in the ‘footprint’ of the Kirkintilloch relief road in 2007 were also incorporated in this project. The mitigation plan necessarily involved the translocation of water voles from the site to suitable receptors nearby. Various locations in the vicinity were considered, but none was deemed suitable.

The discussions centred around the possibility of developing a larger landscape reintroduction project in the upper part of the River Forth catchment near Aberfoyle. FES has substantial land ownership in this area and was keen to develop a water vole reintroduction project given that there is considered to be no prospect of natural recolonisation within the foreseeable future. This view was endorsed by the Water Vole Working Group of LLTNPA, where only a few isolated populations are known to remain.
The Water Vole Conservation Handbook (Strachan et al., 2011) provides the rationale for the circumstances in which reintroduction of water voles might be considered to be an appropriate conservation tool. It also details best practice with regard to undertaking a reintroduction according to the 1998 IUCN Guidelines for Reintroductions (a revised version has subsequently been published, IUCN (2013)).

The guidance in an earlier edition of the Water Vole Conservation Handbook was used as the basis for formulating a project plan to address each of the following criteria, based on the IUCN guidelines:

1. Evidence of former occurrence.
2. Knowledge of cause of extinction.
4. Suitable habitat remaining.
5. No/minimal impact on donor population.
6. Donor individuals genetically as similar as possible to original population.
7. No detrimental impact on remaining native habitats and species.

The original donor population for this project was derived solely from Scottish founder-stock bred from animals captured at Kilgarth and Kirkintilloch. The receptor site falls within the recommended maximum 50 km distance for sourcing animals as described in the Water Vole Conservation Handbook.

It should be noted that more recently a Scottish Code for Conservation Translocations, and accompanying guidelines, have now been produced (NSRF, 2014). This sets out the approach to be taken when planning and carrying out reintroductions and other types of conservation translocation in Scotland.

Location of work

The location and extent of the project area and the release sites are shown in Fig. 1.

The release sites were chosen based on the quality of wetland habitat, suitability for water voles and ease of protecting the site from mink.

Site 1: Duchray Bridge

This site covers a 1 km stretch of the upper Duchray Water. This slow-flowing, meandering section of the river had the conifers removed from the banks more than five years earlier, allowing a rich swathe of emergent and bank-side vegetation to colonise. This is dominated by soft rush (Juncus effusus), bottle sedge (Carex rostrata), purple moor-grass (Molinia caerulea) and abundant yellow water-lily (Nuphar lutea) in deeper water. There are high banks with extensive areas available for burrowing. The river does flood during times of heavy rainfall, however there is a complex network of well-vegetated drainage channels feeding into the river from the surrounding higher areas, providing a refuge for water voles in times of flood.

Site 2: Comer

This site covers a 1 km stretch of the upper Duchray Water and also includes Loch Dubh. The water here is slow and meandering with diverse wetland vegetation covering a wide area, ranging from 3 m to 50 m width on either side of the watercourse. There are high banks with plenty of opportunity for burrowing, and the presence of historical burrows at this site demonstrates its high suitability. The lochan provides additional areas of vegetation for food and cover, including large areas of bottle sedge. The area of suitable habitat beyond the FES boundary extends at least 2 km upstream, including the last recorded historical site in this area, Shady Glen. The upper Duchray is prone to flooding during periods of heavy rain although there are plenty of opportunities for voles to seek refuge from high water in surrounding drainage channels and smaller tributaries feeding in from higher ground.

Site 3: Aquaduct

This site comprises six large ponds adjacent to the Duchray Water. Five of these were excavated in 2006, the other is an old fire pond that has existed for many years. The ponds have been specially created with large earth banks at the margins to allow for burrowing. This site has also been seeded with a variety of favoured wetland species using a pond and wetland seed mix, including species such as yellow flag (Iris pseudacorus). There is also a diversity of grass and sedge species present such as tufted hair-grass (Deschampsia cespitosa) and green-ribbed sedge (Carex binervis). This relatively young wetland habitat will develop further vegetation over the coming years, however it was thought that the level of vegetation in 2008 was sufficient to provide good food and cover for released water voles.
Site 4: Lime Hill

Lime Hill (Fig. 2) is an extensive wetland area of around 12 ha with a large lochan and approximately 15 smaller ponds. This area has been enhanced over the past five years by increasing the size of the lochan and digging out new ponds that are now well developed with a good cover of vegetation, including soft rush and a dense area of reeds (*Phragmites australis*). There is also a network of small burns and drainage channels across the site providing a diverse and highly suitable habitat for water voles. Wetland plant translocation and seeding has also been carried out to enrich the site vegetation with species such as yellow flag, bulrush (*Typha latifolia*) and branched bur-reed (*Sparganium erectum*).

Fig 1. Map showing the location of water vole release sites between 2008 and 2011 (The background map shows 1 km grid squares).

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Fig 2. Lime Hill: an example of the type of habitat that has been established for the releases.

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Site 5: Clashmore Lochan

This is a large natural lochan with a perimeter of around 500 m. There is good vegetation cover surrounding the lochan with a reed bed 1-5 m wide. There is an abundance of greater tussock sedge (Carex paniculata) around the water margins amongst the rich swathe of other sedges and grasses. There is a small burn feeding into the loch that has excellent habitat conditions: slow moving water, high banks and plenty of vegetation cover. These conditions are present for around 100 m before the burn enters an area with dense conifers and becomes increasingly unsuitable. This site is linked to the Lime Hill site via the network of burns in the area that should facilitate dispersal between these sites.

From 2009 to 2011, further smaller-scale releases were carried out at another 10 sites, shown in Fig. 1. These sites were identified using the same criteria as previously and were selected for their location with the intention that dispersal between the Lime Hill population and the Duchray Water population would become possible. These two separate water systems may have been difficult for voles to travel between, so by releasing animals into the vacant areas the establishment of a functioning metapopulation could be facilitated. Thus animals from different sites would find each other and be able to breed.

Methods and techniques

Sixty water voles were captured from Kilgarth in 2006 and transferred to a captive breeding facility in south-west England operated by the Derek Gow Consultancy. The animals were isolated from other captive water voles, to control breeding and maintain the genetic integrity of the Scottish animals. In 2006 the captive founder animals from Kilgarth produced 107 juveniles. These were re-paired in the spring of 2007. By November 2007 there were 276 individuals (adults and young) still alive. These were paired again to provide the August 2008 release population of 591 animals in total. The trapping and breeding of animals was undertaken in accordance with the guidance in the Water Vole Conservation Handbook (second edition) (Strachan and Moorhouse, 2006). This complies with the husbandry, record-keeping and health screening requirements of a captive breeding programme. A number of animals were kept in captivity to breed and subsequently provided the 2009 release population of around 290 voles and a 2010 release population of around 60 voles.

The first releases took place in mid-May 2008, at Duchray Bridge. The timing of this was ideal as it coincided with maximum early summer abundance of vegetative food and cover. Water levels are less

Breeding water voles in captivity

(See also Dean et al., 2016)

The water voles were maintained in wooden-framed cages 1.8 m long x 1.2 m high x 1.2 m wide. These were internally wired with 13 mm-square weldmesh to ensure that no wood was exposed. They were provided with a conventional small straw bale at the back of each pen to afford nesting cover. This was protected against the weather with a section of corrugated sheet tin at a 45° angle to provide cover from the weather. The front floor space was mulched with wood bark to a depth of approximately 15 cm to provide a burrowing substrate. A water tray was placed at the front of the pen in the summer months to provide swimming opportunities. This was constructed from gnaw-proof plastic and was approximately 5 cm deep. A separate drinking bottle was attached to the pen side to ensure an uncontaminated drinking supply.

Males and females of the same weight were introduced to each other simultaneously in March. Their daily diet comprised an alfalfa-rich rabbit food in a bowl under the tin cover and a quarter sweet apple and carrot per vole per day. The provision of an exact daily amount of food rose in tandem with the anticipated numbers in the breeding cage. This was approximately assessed by the levels of activity in each. The cages were cleaned out in late June and any large offspring – those over 100 g in weight – were removed for release at this time. All the lighter juveniles were retained in captivity over winter and released in the spring of the following year at a time when the water levels were stable and vegetation re-growth was well underway.
prone to fluctuation at this time of year giving the voles the best chance of establishing at this site.

A total of 185 juvenile and adult water voles were released on a ‘soft’ release basis from release pens (Fig. 3) with daily food support for one week (see also Dean et al., 2016). This soft-release method has been found to be extremely effective elsewhere, with most individuals remaining within 500 m of their release point (Derek Gow, pers. comm.).

Forty release pens were located in areas of good quality habitat along the banks of the Duchray Water. The precise location of each pen was carefully selected within 2 m of the water’s edge. Care was taken to choose release sites where the water level was relatively stable, as severe fluctuations either way can be a critical factor in the success or failure of a colony (Derek Gow, pers. comm.). The position of each pen also ensured that maximum vegetation cover was available for animals emerging from the pens once their anti-predator baffles were in place. The pens were well screened from the sun. These pens allowed the animals to acclimatise to the release site and create burrows under the pen and surrounding area. The location of pens was recorded using a GPS and mapped (Fig. 4). Release pens were approximately 30–50 m apart to replicate territory sizes of individual voles. Voles were released in sibling groups of up to eight animals, or as individual adults, following best-practice guidelines developed from experience of previous releases.

A further release took place in August 2008 at the other four sites (Table 1). This was later than originally planned to enable the juveniles for release to attain an optimum average weight of 120 g. The methods used were the same as outlined for the first stage of the release, the only difference being that pens were placed closer together in pond habitats, as these provide more suitable habitat over a smaller area and can therefore support a higher density of animals (Derek Gow, pers. comm.). For example, the large lochan at Lime Hill has a perimeter of approximately 600 m with drainage channels at each end providing approximately 300 m of linear habitat. Forty release pens were placed in this area of the site at around 20–30 m intervals. On smaller ponds, two or three pens were placed around the perimeter amongst dense vegetation.

Table 1. A summary of the water vole releases. Release sites are shown in Fig. 1.

<table>
<thead>
<tr>
<th>Time of release</th>
<th>No. of voles</th>
<th>Source of donor population</th>
<th>Release sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2008</td>
<td>185 adults</td>
<td>Kilgarth</td>
<td>Duchray Bridge</td>
</tr>
<tr>
<td>August 2008</td>
<td>591 adults/juveniles</td>
<td>Kilgarth</td>
<td>Clashmore, Comer, Aqueduct, Lime Hill</td>
</tr>
<tr>
<td>May 2009</td>
<td>40 adults</td>
<td>Kilgarth</td>
<td>Comer, Lime Hill</td>
</tr>
<tr>
<td>August 2009</td>
<td>250 adults/juveniles</td>
<td>Kilgarth</td>
<td>Drumore Wood, Boninty Burn, Hydrology North, Hydrology South, Bellhouse</td>
</tr>
<tr>
<td>August 2010</td>
<td>60 adults/juveniles</td>
<td>Kilgarth x Glen Lochay</td>
<td>Corriegrennan, Stronmachnair</td>
</tr>
<tr>
<td>May 2011</td>
<td>34 adults</td>
<td>Kilgarth x Glen Lochay</td>
<td>Leannach Ponds</td>
</tr>
<tr>
<td>May 2011</td>
<td>18 adults/juveniles</td>
<td>Kilgarth x Glen Lochay</td>
<td>Hydrology 11, Dead Ponds, Lime Hill 11</td>
</tr>
</tbody>
</table>
The release pen design was chosen because of the presence of pine marten (*Martes martes*) in the catchment. The release pens were constructed of wood, plastic sheeting and 13 mm square weldmesh and could be folded for storage and transport. The pens measured 91 x 67 x 36 cm, providing plenty of space for the animals to move around. They were entirely secure until the point of release to reduce predation pressure during the initial acclimatisation period. These enclosures held the animals for four days, after which they were fitted with a wooden anti-predator baffle. This is a solid board made from 13 mm marine ply with two 4 cm holes in the lower corners, which allow the voles to come and go whilst excluding pine martens. All release cages were supplied with abundant bedding and chopped apples and carrots for food and moisture. Details of all animals released were recorded including sex, age class, weight and the location of release (pen number).

**Monitoring**

Since the initial release, full surveys have been carried out each year on all release sites involving detailed examination of the river banks, pond edges and adjacent drainage channels. This is done between April and October when water vole activity is most evident. The water level is less prone to fluctuation at this time of year, allowing the development of many burrows throughout the most suitable sections of habitat.

In addition to surveying the release sites, possible dispersal sites are also surveyed annually. Habitat surveys to identify suitable dispersal sites can be undertaken all year round, as long as there is no snow cover. The selection of possible dispersal sites begins with a desk-based exercise which involves identifying all water features and possible wetland habitat within a 3 km radius of each release site on a 1:25,000 Ordnance Survey map. Areas with too steep a gradient to provide suitable habitat for water voles are rejected (as detailed in the *Water Vole Conservation Handbook*). An initial assessment
of vegetation is made by consulting the FES species composition database and using local knowledge of sites. Surveys are not carried out where conifers are known to grow to within 1 m of the water’s edge.

Once the desk-based exercise has been completed the possible dispersal sites are visited and habitat assessments made using the five criteria below, as outlined in the Water Vole Conservation Handbook.

- High (rather than short or sparse) grass cover.
- Slow (rather than still or fast flowing) water.
- Narrow watercourses (defined as less than 3 m).
- A bed substrate of sand or pebbles (rather than silt, gravel, boulders or solid rock).
- Bank soils that are penetrable rather than hard.

The most suitable habitat areas are identified, mapped, and prioritised for survey in spring or summer as ‘suitable habitat patches’. Sites that have recently been restored and are not yet suitable, but which are likely to become suitable once trees are felled and vegetation recovers, are also identified for future surveys. If time and resources allow, sites more than 3 km from release sites and known colonisation sites are also assessed for suitability.

Surveys during the winter enable the identification of ‘habitat patches’ that meet these characteristics within 3 km (‘Euclidean distance’, i.e. straight-line) of all release sites and known colonisation sites. This distance has been selected as it is higher than the known mean dispersal and should, therefore, minimise the chances of missing new colonies, but may be practically achieved with the available resources. The mean dispersal distance in upland water voles is 1.8 km (Fisher et al., 2009) although they may disperse up to 8 km (Xavier Lambin, pers. comm.). A Euclidean distance is used as water voles readily disperse directly overland in any direction without being constrained by the availability of riparian habitat (Fisher et al., 2009).

**Water vole distribution**

Full field-sign surveys were undertaken at each of the release sites between March and October in each year since the project began. All other sites that have been naturally colonised or identified through the habitat assessment process were surveyed using the presence/absence method. The two survey methods employed are detailed below.

---

### The full survey method

A series of maps and aerial photos are produced showing linear water features divided into 100 m sections and wetland features into 10 m x 20 m blocks, labelled with individual codes. Areas too steep for water voles are identified following the guidelines in the Water Vole Conservation Handbook and are omitted from the surveys. Each section/block is assigned to a trained surveyor and thoroughly searched for water vole signs. Surveys on linear features are usually carried out from the top of the bank (and include the area up to 3 m from the bank edge) but if necessary waders are used to access the water to obtain a good view of the banks and water’s edge. Other wetland features require a systematic search. The survey records sightings, sounds of voles entering the water (‘plops’), latrines showing discrete piles of droppings, burrow entrances, cropped lawns near burrows, feeding stations, runways in the vegetation and any footprints. The number of water vole field signs are ranked as abundant, frequent, scarce or none. Latrines are counted and used as an indication of the density of breeding individuals.

At all other sites a simple presence/absence survey method was employed. The decision to do this was made on the basis that reducing the time spent at each site would allow more sites to be covered. Presence/absence surveys were undertaken on all known colonisation sites, where water vole tracks had been found on mink rafts within 500 m of a known water vole colony, and at as many sites as possible classified as ‘high’ or ‘medium’ suitability by the habitat surveys carried out over winter 2010. They were also carried out at some sites that had not had habitat surveys but were good water vole habitat, or where water vole sightings had been reported.
Reducing the potential for inbreeding depression

It was agreed that the addition of animals from a variety of sites would benefit the genetic diversity of the breeding stock and reduce the likelihood of inbreeding depression, as recommended in the Water Vole Conservation Handbook. Therefore a potential donor site was identified in Glen Lochay, Stirlingshire where there is a robust breeding population. This site also falls within the recommended maximum distance (50 km) for sourcing animals. With permission from the landowner, water vole traps were set in September 2009 and operated according to best-practice guidelines (Gurnell and Flowerdew, 2006; Strachan and Moorhouse, 2006). The captured animals were weighed and any exceeding 170 g were immediately released at the point of capture. Animals weighing less than 170 g were sexed and transferred to individual cages provisioned with bedding and food. By 24 September six underweight juveniles (three males and three females) had been captured and were transferred to the Derek Gow Consultancy breeding facility. They were over-wintered and paired in spring 2010 with animals descended from the Kilgarth captive breeding population. Offspring from these pairings formed part of the 2010 release cohort. Any animals that did not reach 120 g before the release were retained in captivity and bred the following spring for release in 2011.

Mink control

The monitoring and control of mink in and around the reintroduction sites has been a key part of the project. This has been carried out using Game & Wildlife Conservation Trust mink rafts set at 1 km intervals or less. Initially 17 mink rafts were put out on the Duchray Water and some of its tributaries between Aberfoyle and Ben Lomond. Rafts were also placed on the Kelty Burn to cover the first reintroduction locations and likely dispersal routes for mink entering the forest. Mink rafts were put in place in 2007, providing the opportunity to collect information on the distribution and abundance of mink within the area and enabling population control to be carried out. Rafts are checked every two weeks and results recorded on a spreadsheet. Other wildlife signs are also recorded. If a mink sign is detected then traps are set immediately on that raft and others in the same area if appropriate. Traps are checked daily and if there is no capture within 10 days the raft is returned to monitoring mode but checked more frequently than before in

The presence/absence survey method

The methods employed in the presence/absence surveys are almost identical to the full survey. Notable exceptions are that once a latrine, footprints or visual confirmation of an animal has been identified within a 100 m section then the surveyors record the presence of water voles in the area, the full survey of the section stops and the surveyors move on to the next section. To avoid subjective and anomalous results caused by misidentification, only latrines, footprints or an actual sighting can give a positive result for an area. Should there be no latrines, footprints or sightings identified, then a full survey is still conducted recording any feeding signs, burrows or pathways in the vegetation that may be seen and the area is given a ‘possible’ result. Should no signs be found then the area is given a negative result.

Care is needed to ensure that footprints detected are those of water vole. Footprints are not a reliable field sign in areas where brown rats (Rattus norvegicus) are present as they are easily confused. Fortunately, there was no evidence of rats at the majority of the water vole sites.

Burrows, runs and feeding signs, in the absence of other conclusive evidence, were recorded as evidence of ‘possible’ presence because of the potential for feeding signs to be confused with those of field vole (Microtus agrestis), and runs and burrows persisting when water voles are no longer present. In some areas it is very difficult to systematically search for signs and it is likely that latrines/droppings were missed owing to changing water levels, undercut banks and the presence of old stumps and root-plates making accurate surveying very difficult.
the following weeks. Trapped mink are humanely dispatched according to best-practice guidance.

Mink control had also been carried out prior to the mink rafts being deployed, on a much smaller scale using targeted bank-side trapping where regular mink signs were found (Table 2).

Trapping effort has increased each year as the area monitored has expanded. Since 2010, the number of trapped mink has remained low with animals only being caught in peripheral areas. Loch Ard Forest, the main reintroduction area, is considered to have been mink-free since 2010. A slight increase in captures in 2012/13 was due to expansion of mink rafts into a new area to the north-east of the project area, near Callander. In 2015, over 20 new raft locations were established outwith the original project area resulting in another sharp increase in captures. Mink rafts are now in place giving opportunities to control mink in over 100 km squares, as shown in Fig. 5. A number of these are on private ground outside the FES boundary and are monitored by private landowners.

Table 2. Mink captures at all sites from 2002 to 2015. References to ‘traps’ indicates years when bank-side traps were used instead of rafts.

<table>
<thead>
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<tr>
<td>Number of mink trapped</td>
<td>8</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>10</td>
<td>14</td>
<td>9</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Number of rafts</td>
<td>3 traps</td>
<td>3 traps</td>
<td>3 traps</td>
<td>3 traps</td>
<td>17</td>
<td>29</td>
<td>54</td>
<td>72</td>
<td>68</td>
<td>66</td>
<td>65</td>
<td>74</td>
<td>95</td>
<td></td>
</tr>
</tbody>
</table>

Fig 5. The location of mink rafts operating in 2015 (The background map shows 10 km grid squares).

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Problems and solutions

Overall the project has been a great success as water voles are now breeding throughout suitable habitat areas along the Duchray and Kelty Waters as well as colonising many new sites up to 12 km from the release areas (see the ‘Results’ section below for more details). As with other similar projects involving continuing mink control, long-term resourcing is an issue, as the network of mink rafts needs regular monitoring to ensure that they are working effectively. FES has undertaken to continue the operation and maintenance of mink rafts on their land, but further expansion of the control effort requires continued additional resources. Long-term habitat management is also essential to ensure that the water voles’ habitat remains free from tree encroachment. FES is striving to maintain the quality of the wetland habitat area in the core water vole sites but the available resources for this work are limited.

Another issue is the dispersal of voles into areas outside FES ownership. Although it is clearly a measure of the overall success of the project that voles are spreading naturally into new areas, it can be difficult to monitor these sites and there can be issues with mink control if this is not supported by private landowners. This will limit the water voles dispersal beyond the current project area and into the wider landscape where mink are not controlled. So far, this has been tackled by raising awareness among the public of the plight of the water vole and the need to control mink. The project has received some additional funds from LLTNP in 2015 and 2016 to help pay for a new Project Officer in partnership with FES and the River Forth Fisheries Trust. Further resources are now needed to continue to develop this crucial aspect of the project.

Another issue has been the use of mink rafts by other similar-sized mustelids. The tracks of polecat (*Mustela putorius*), ferret (*M. furo*) and pine marten can be very difficult to distinguish from mink tracks when they are in wet clay. If such tracks are detected on rafts, traps then need to be set and checked daily. This is time-consuming work. Four pine martens and three polecats have been captured to date, and subsequently released, as well as several other non-target species (Fig. 6). This issue is being addressed by placing camera-traps on rafts when tracks are detected in places where martens and polecats are known to be present. This works well if the camera can be placed safely above fluctuating water levels.

![Fig 6. A polecat incidentally captured in a mink trap.](image_url)
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Table 3. Changes in water vole occupancy in the project area between 2008 and 2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cumulative number of release sites (total)</th>
<th>Number of sites with evidence of breeding water voles in each year (latrines found)</th>
<th>Cumulative number of kilometre squares known to be occupied by water voles within the area shown in Fig.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>2009</td>
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<td>10</td>
<td>10</td>
</tr>
<tr>
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<td>2012</td>
<td>16</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>2013</td>
<td>16</td>
<td>27</td>
<td>45</td>
</tr>
</tbody>
</table>
Results

The results of the water vole field survey carried out each year are summarised in Table 3. There was a statistically significant increase over the period 2008-15 in the number of sites with evidence of breeding, as determined by the presence of latrines, with an average of about five new latrines found each year.

Only three release sites out of a total of 15 did not have water voles recorded in 2012. At each release site, the population has expanded considerably, and often merged with that of a neighbouring release site. In 2015, surveys demonstrated water voles to be present in at least 60 different 1-km squares, and many sites have been naturally colonised by water voles up to 12 km from the original release sites. Fig. 7 shows the recorded water vole distribution between 2008 and 2014 in and around the Queen Elizabeth Forest Park. This includes records from the release sites, combined with the subsequent new colonies established further afield. Fig. 7 does not give an indication of the numbers of voles present, because the overall aim of the project was to establish a breeding population that persists over time. Knowing the number of animals is not required to demonstrate this, but evidence of an increase in site occupancy over time (Table 3) is sufficient. Comparison between Fig. 7 and Fig. 1 (which shows the original release sites) demonstrates the extent of natural colonisation and the distance of dispersal.

There are known limitations to the survey methods for identifying water vole presence and the dispersal of animals away from release sites. Surveying is only effective when carried out during dry periods to enable field signs to build up. During heavy rain, field signs can be washed away, making it difficult for water voles to be detected, especially at the start of the breeding season when numbers are naturally at their
lowest, thereby resulting in false negatives. It is also impossible to predict the dispersal routes of young animals as they are known to travel over large areas of unsuitable habitat in search of new areas to colonise (Aars et al., 2006). This makes the detection of newly established populations challenging and it is presumed that an unknown proportion of naturally colonised new sites have yet to be surveyed, especially in areas outside the FES boundary.

**Lessons Learnt, Further Work and Future Recommendations**

One issue that emerged following the initial releases concerned the number of animals that were released and the area of habitat that was available to them. Based on advice received from the Derek Gow Consultancy, 591 animals were released in 2008 into extensive areas totalling approximately 1.6 km$^2$ of high quality water vole habitat, i.e. around 2-3 voles/ha. High density populations occur in productive lowland habitats, particularly further south in Britain. For example, in wet carr and reed bed sites in Dorset and Suffolk, water vole densities have been estimated at 40-50 per ha and 25-30 per ha respectively (Strachan et al., 2011). However, in upland areas of Scotland, population densities in the breeding season are generally very low, typically less than 5 per km$^2$ (less than 0.05 per ha) (Aars et al., 2001). Although the habitat at the release sites is essentially ‘upland’ in character (even though the altitude is only 100-150 m a.s.l.) it is considered to be substantially more productive than that typically utilised by voles in the Cairngorms or north-west Sutherland. However, concerns were raised during the project over whether the area was sufficiently productive to support the numbers released. An unknown proportion of the released animals will have dispersed into adjoining areas and some of these are likely to have been predated in the process.

It is difficult to estimate the carrying capacity of a particular site as there are many complex variables that contribute to the quality of the site and its suitability for voles. Therefore, any assessment of the receptor site(s) needs to be as comprehensive as possible in order to reliably inform the numbers of animals for release. This should include a review of the available information on vole density at other comparable sites. It is likely that the new colonisers will rapidly respond to the high availability of resources and show rapid population increase. Therefore it may be beneficial to release animals at a lower density than the carrying capacity of the site. In the Trossachs project the majority of releases resulted in long-term establishment of water voles and so can be considered as successful.

Another important issue is the ability to control mink in the long term and over the wider landscape. Water voles are colonising new sites each year, many of which are beyond the existing mink control area. This issue needs to be tackled via a wide reaching co-operative approach with help from all land owners, something beyond the remit of FES. This approach needs to be driven forward by an appropriate umbrella organisation with an allocation of long-term financial resources to support this work. Without this type of action, the spread of water voles from the release areas will always be restricted. The strategic landscape scale approach to mink control outlined in the American mink chapter of this handbook provides a framework for how this might operate in future, should the resources become available to enable southward expansion of the Scottish Mink Initiative area from north Tayside into the Trossachs.

**Progress since the end of SAF**

A new partnership has been established and in 2014 the River Forth Fisheries Trust (RFFT) joined the project with RZSS stepping down. This has enabled the recruitment of a new Project Officer with some additional funding from the LLTNPA contributing to the majority funding from FES. As a result, many new mink-raft locations have been established with help and support from private landowners. These rafts have been targeted in areas where water vole colonisation is most likely or has already begun, allowing their distribution to increase considerably. Mink control has become the primary focus of the Project Officer as this is the single largest inhibiting factor for the spread of the reinstated water vole population. Many new landowners are now involved, along with organisations such as the Royal Society for the Protection of Birds and the Woodland Trust.

Monitoring the water vole population continues on an annual basis with continued support from LLTNP staff and volunteers. As the voles spread further away from the initial release sites into privately
owned estates, it becomes more challenging to track their dispersal. With the detection of new colonies each year, it is becoming increasingly apparent that water voles are thriving once again in the Trossachs and beyond.

Further Information


http://www.snh.gov.uk/protecting-scotlands-nature/reintroducing-native-species/scct/ – the Scottish Code for Conservation Translocations. Although not published at the time of the Trossachs Water Vole Project, any future translocations will need to comply with this.


References


Acknowledgements

This project would not have been possible without the driving enthusiasm and expertise of Derek Gow. It is also important to thank the many volunteers who have contributed to field surveys, Gareth Kett from Loch Lomond and the Trossachs National Park Authority for his dedication to surveys and organising the volunteer work and Gwenda Diack for her help on the steering group. We would also like to thank David Anderson for initiating the project and for all his help and support throughout the project. The Project Officers, Anna-Marie Dennis and James Silvey, also deserve special thanks for all their hard work during their time with the project.

The SAF Partners

- Scottish Natural Heritage
- Forestry Commission Scotland
- Loch Lomond & The Trossachs National Park Authority
- The Royal Zoological Society of Scotland
- The Derek Gow Consultancy
- The Kilgarth Development Company

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Vendace

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Summary

• Vendace (Coregonus albula) is the rarest freshwater fish in the UK. At present it is naturally extant in only two freshwater lakes. It was previously recorded in two water bodies in southern Scotland, but both populations perished.

• Action for vendace under the Species Action Framework (SAF) focused on six main areas:
  – Identifying new receptor sites for translocation.
  – Obtaining vendace for translocation.
  – Carrying out genetic analyses of vendace populations.
  – Establishing assessment techniques for spawning habitat.
  – Assessing population size at Loch Skeen.

• The restoration of vendace to new sites in Scotland has been successful in Loch Skeen, whereas the establishment of vendace in two additional sites (Daer Reservoir and Loch Valley) requires further assessment. This supports the view that translocation exercises for rare freshwater fish require long-term funding commitments.

• Experience of applying the site-selection criteria described in conservation translocation guidelines to identify new receptor locations for vendace conservation introductions, suggests that options for new sites may be limited to artificial water bodies or those recovering from acidification.

• This work, which involved co-operation between agencies in both Scotland and England, was only possible through the formation of a steering group comprising government agencies (Scottish Natural Heritage (SNH), Environment Agency, Natural England), research institutes (Centre for Ecology & Hydrology (CEH)), academia (Universities of Glasgow and Queens University Belfast) and specialist external consultancies.

Introduction

Species background

Vendace (Coregonus albula), together with powan (Coregonus lavaretus), are temperate ‘whitefish’ which belong to the family Coregonidae. Both species occur in many lakes in north-west Europe and their distribution extends from northern Scandinavia and north-west Russia in the north to Bavaria further south, and from Cumbria in the west to western Russia in the east.

The rarest freshwater fish in the UK, vendace has a very restricted indigenous range, and is only known to have been present in four locations. Two of these are in south-west Scotland (Dumfriesshire) and two in northern England (Cumbria). Both Scottish populations, at Castle Loch and Mill Loch, were lost during the last century. The population at Castle Loch was lost shortly after the installation of a new sewage works in 1911 (Maitland, 2007). The Mill Loch population was lost sometime between 1966 and the mid-1970s (Maitland and Lyle, 2013), possibly because of a decline in water quality and the introduction of non-native fish species.

In England, the vendace population in Bassenthwaite Lake was considered to have been lost in 2008 as a result of eutrophication, increased sedimentation on spawning areas, and non-native fish introductions. However, a single juvenile fish was caught there in 2013, and it is not known whether this individual is a remnant of the original population or the product of a recent colonisation event. Connectivity exists between Bassenthwaite Lake and Derwent Water, and it is possible that vendace (larvae or fry) may have entered Bassenthwaite Lake via the River Derwent. Further sampling resulted in the capture of two adult fish in 2014 and one in 2015, suggesting that the Bassenthwaite population continues to exist, but in low numbers (Winfield and Gowans, 2014).

Taxonomy

‘Lochmaben vendace’ (from Castle Loch and Mill Loch) was originally described as a distinct species and subspecies, Coregonus vandesius vandesius. The two vendace populations in northern England (at Bassenthwaite Lake and Derwent Water) were referred to as the Cumberland vendace, Coregonus vandesius gracilior (Regan, 1911).
All these stocks are now considered to belong to a single species, *Coregonus albula* (Ferguson, 1974). A more recent examination of coregonid taxonomy (Kottelat and Freyhof, 2007) supports the view that the vendace populations of both Lochmaben and Cumbria are, indeed, *C. vandesius* rather than *C. albula*. However, this is based solely on the morphological characteristics of a genus that exhibits considerable intra- and inter-population phenotypic variation, and is not supported by the (albeit limited) genetics data available. A typical adult vendace is shown in Fig. 1.

Fig 1. An adult vendace. © Peter Maitland

General ecology

Vendace habitat is typified by large, deep, standing waters that allow access to relatively cool-water refuges with high oxygen levels. The species also requires clean gravel or stony substrates at depths of less than 4 m for spawning. Spawning typically takes place from late November to mid-December. The young hatch out during March or April, depending on water temperature. Vendace is a shoaling species that feeds primarily on zooplankton, although larger fish may also include macroinvertebrates in their diet.

Habitat management

It is clear, from the impact that poor water quality has had on vendace in Scotland and Bassenthwaite Lake, that the maintenance of high water quality is important for the species’ survival. Reducing the input of nutrients, particularly phosphorus, is essential if eutrophication, and temporal reductions in dissolved oxygen in deep-water refuges, are to be prevented. Avoiding the introduction of invasive non-native (including locally non-native) fish species, which may either compete for resources with, or prey on, vendace, is also important. The introduction of invasive plants such as New Zealand pygmyweed (*Crassula helmsii*), which can blanket vendace spawning areas, may also have an adverse impact on this species (Lyle and Maitland, 2011).

Guidelines for conservation translocations

The International Union for the Conservation of Nature (IUCN) first produced ‘Guidelines for Reintroductions’ in 1998. These became the basis for the Joint Nature Conservancy Council (JNCC) policy paper on conservation translocations in Britain, published in 2003. The approach set out in the JNCC (2003) document was therefore applied when carrying out the SAF work on vendace described in this chapter.

Since SAF finished, there have been two further significant developments in recommended best practice for conservation translocations. The first was the revised guidelines produced by the IUCN (2013). The second, based on the IUCN (2013) guidelines, was a Scottish Code for Conservation Translocations, and accompanying best practice guidelines, produced by the National Species Reintroduction Forum (NSRF) in 2014. Application of the Scottish Code is now mandatory for all conservation translocations that require licences from SNH.

Action implemented before 2007

The first translocations of vendace in the UK followed a five-year Nature Conservancy Council contract for research on freshwater fish conservation which ran from 1987 to 1992. This work, which pre-dated IUCN (1998, 2013) and other reintroduction and conservation translocation guidelines, led to the introduction of 8,379 un-fed vendace fry, obtained from Bassenthwaite Lake, to Loch Earn in 1989. The success of this translocation was never fully assessed and, based on the fact that Loch Earn supported a population of Arctic charr (*Salvelinus alpinus*), current conservation translocation guidelines would have ruled out the use of Loch Earn for this purpose. An adult vendace from Loch Earn caught by an angler in 2005 provided some evidence that individuals remained within the lake. As this fish was aged
5+ at capture, and hence belonged to a cohort hatched after the 1989 introduction, it showed that the translocation had resulted in a spawning vendace population.

Before SAF there was a ‘Species Action Plan’ for vendace within the framework of the UK Biodiversity Action Plan (UKBAP). This had three main objectives, which were to:

- Ensure that practical action is taken to maintain the survival of the species in Bassenthwaite Lake, Derwent Water and Loch Skeen.
- Establish a self-sustaining population in a second water body in Scotland by 2010 and further populations at an additional two sites by 2020.
- Establish a self-sustaining population in at least one additional Lake District water by 2010.

Of 110 water bodies in south-west Scotland screened for their suitability to support vendace, only two, Loch Skeen (Fig. 2) and Daer Reservoir, were considered to be immediately suitable as permanent sites for new conservation introductions (Lyle et al., 1998). Following the site selection process, 65,000 un-fed vendace fry and eggs from Bassenthwaite Lake were introduced to Loch Skeen in 1997 and 1999. A total of 12,800 un-fed fry derived from Derwent Water vendace were also introduced to Daer Reservoir (South Lanarkshire) in 1998. A small-scale post-introduction monitoring survey in 2003 confirmed that the vendace introduction to Loch Skeen had been successful, and that a self-sustaining population had become established. A similar survey carried out at Daer Reservoir in the same year failed to find similar evidence of establishment, and it was thought that a small stock of vendace may have survived, but below a level that is readily detectable.

During 1999, the Environment Agency commissioned a translocation feasibility study to locate sites for vendace introductions in Cumbria. Of 87 sites examined, none was found to be immediately suitable (Lyle et al., 2005). Further work identified Sprinkling Tarn in Cumbria as a translocation site and 130,000 eggs from Derwent Water fish were introduced there in 2006. A further 30,000 eggs and 25 adult vendace were translocated to Daer Reservoir as part of this work (Lyle et al., 2006).

Aims

Aims and objectives for 2007-2012

The SAF Implementation Plan for vendace included four broad objectives. These were to:

- Take practical action towards the continued survival of the species in Loch Skeen.
- Target receptor sites for the establishment of further refuge populations of vendace.
- Once established, monitor these sites and take appropriate action to protect new populations.
- Increase public awareness of vendace and the need to protect it.

Management Action

Action implemented since 2007

To achieve these aims, a steering group was developed which included all of the partners already involved with the delivery of the UKBAP Species Action Plan for vendace. This partnership included individuals from the University of Glasgow, CEH, Queens University Belfast, Barony College, SNH, Environment Agency, Natural England, Marine Scotland Science, and external species specialists (Peter Maitland and Alex Lyle).

The steering group met at least annually and occasionally twice per year, to review the work undertaken and help steer future work. The following actions were carried out, as described further below:
Establishing new vendace populations in Scotland

- **Identifying new receptor sites for conservation translocation** by re-assessing data collated for previous translocation work and identifying those that may have potential for new introductions, using the guidelines available at the time. This work was expanded to include an assessment of previously acidified sites in southern Scotland.

- **Obtaining vendace for conservation translocation.** The Loch Skeen population was established using vendace from Bassenthwaite Lake, a population now believed to be in danger of extinction. Additional work centred on the use of Derwent Water as a donor site.

Getting the science right – key scientific challenges

- **Genetic analysis.** It is important that new receptor sites reflect the genetic variability within the donor population. This work focused on the identification of appropriate markers and also attempted to use genetic data to derive the ‘effective population size’ of vendace populations.

- **Investigating food webs using stable isotopes.** Stable isotope analyses were used to identify the trophic position of newly established vendace within freshwater lochs – using Loch Skeen as an example.

- **Going beyond the IUCN Guidelines - new habitat assessment techniques.** This work explored the potential for the development of a new assessment protocol for vendace spawning-habitat. This involved the use of underwater video mounted on a Remotely Operated Vehicle (ROV).

- **Assessing population size at Loch Skeen.** The population of vendace in Loch Skeen was assessed using a standard Site Condition Monitoring protocol developed by Bean (2003) to establish a baseline for future comparisons.

Identifying new receptor sites for translocation

The selection of new receptor sites for translocations is not a simple task. The 110 potential sites considered at the start of the vendace conservation project resulted in the identification of only two suitable sites. During the period covered by SAF, the IUCN (1998) and JNCC (2003) conservation translocation guidelines were applied in selecting potential donor sites. These were not previously available. These translocation guidelines recommend that new receptor sites should be located as close to the donor site as possible. Thus, for vendace a receptor site would need to be found either within the same catchment, or within the same hydrometric area. Although this proved impossible to achieve, this requirement limited both the search area and the number of sites that could be brought forward for further consideration.

In 2007/8, the suitability of the 110 waterbodies previously considered in the south-west of Scotland in 1996 was reassessed, in the expectation that sites considered to be marginally unfavourable then, might have since become suitable. Many of the waters that were considered to be unfavourable continued to be so. However, 10 sites that had been rejected earlier because of acidification or the associated risks of heavily afforested catchments merited reappraisal because of observed recovery from acid conditions. For many acidified waters, their recovery was not yet adequate for vendace introduction, but if present rates of recovery continue, they may become so in the next few years. Two sites, Black Esk Reservoir and Loch Valley, had previously been rejected because of impacts related to closely surrounding forestry and acidification, respectively. Loch Trool, which is connected to Loch Valley, was also considered to be suitable. These sites were more intensely examined and were found to satisfy most of the criteria for a permanent vendace conservation introduction exercise, and this was planned for 2008.

Several key factors affect the selection of a receptor site for the translocation of vendace. Further details were provided by Lyle et al. (1996) and subsequent reports, but in brief these are:

a) **Area/size.** In general, larger waters, simply by virtue of their size, are more resistant to change by external influences and possess more stable thermal regimes. They are capable of supporting larger fish populations and are more likely to contain substantial deep water refuge areas.

b) **Altitude.** Considering its northern European and Scandinavian distribution, vendace is clearly a cool-water species. Site altitude was considered relevant because of possible warming from long-term climate change. High-altitude sites may have a lower risk of increased temperature and enrichment than low-altitude water bodies. These higher altitude waters should also be
more secure and less likely to be threatened by public or commercial pressures.

c) Depth. A minimum depth requirement was set at 5 m since shallower waters are unlikely to provide the necessary refuges described above. Also, shallow waters are more susceptible to periods of elevated temperature and episodic pollution.

d) Availability of suitable spawning substrate. Optimal spawning substrate for vendace includes stony substrates, ranging in size from gravel to boulder (2 mm to more than 256 mm diameter), comprising at least 30% of the spawning area, with less than 10% of the area assessed covered by sedimented organic silt.

e) Competition from other fish species. It would be an undesirable risk to attempt to establish vendace, which is a planktivorous fish, in waters that hold established populations of piscivorous fish species such as pike (Esox lucius) or perch (Perca fluviatilis). Neither would it be advisable to introduce vendace to waters where bottom feeders such as ruffe (Gymnocephalus cernuus) may consume vendace eggs. Similarly, but to a lesser degree, species that would directly compete with vendace for food, such as roach (Rutilus rutilus), should be avoided. It should be noted that vendace and pike coexist in other waters. However, it is most likely that pike arrived after vendace had become established and the interactions between these species must be in balance. The presence of pike is certainly an unwanted pressure on the establishment of new vendace populations but given the shortage of appropriate waters, some sites that contain pike but are otherwise suitable may have to be considered seriously in future. Sites heavily stocked for angling or with an intense angling interest are usually unsuitable because of unnaturally high pressures of feeding competition and predation of vendace eggs and fry. There is also a heightened risk of disease and parasite infestation. In addition, necessary periodic monitoring of the introduced vendace stock by gill-netting may not be acceptable to fishery owners.

f) Rare fish species. It would be unacceptable to take conservation action for one rare species to the detriment of another. Within the area of interest (southern Scotland) there are no known waters in this category but there are four waters that once held rare or endangered species and these were excluded on principle. These were two sites known previously for Arctic charr (Loch Dungeon and Loch Grannoch), which may be considered for reintroductions of Arctic charr in future, and the two earlier Scottish sites for vendace (Mill Loch and Castle Loch). Both are now clearly unsuitable, being highly eutrophic with substantial populations of coarse and predatory fish. Restoration of these sites is likely to be prohibitively expensive and impractical (Lyle et al., 1998).

g) Acidification. Several waters in south-west Scotland are known, from previous studies, to have been severely affected by acidification to the extent that all fish have been lost. Such waters were not considered by Lyle et al. (1996) as being candidate introduction sites; however, some recovery from acid conditions has been reported in several of these. Waters showing significant recovery from acidification had to be reconsidered, therefore, as potential sites for conservation introduction.

h) Forestry. Waters with a high proportion of their catchment used for commercial forestry were not considered suitable by Lyle et al. (1998), particularly if the forest encroached close to the loch shore. At that time commercial forestry was associated with vulnerability to acidification. Such waters are also considered to be at high risk from sedimentation of shoreline substrates, enrichment from artificial fertilisation and occasional pollution events. However, with the acidification threat now diminished, sites where forestry is the only detrimental feature were reconsidered individually.

i) Reservoirs and impounded water bodies. Public water-supply reservoirs provide potable water of high quality and are also protected from damage and pollution. For vendace it is important that water levels are kept high and reasonably stable during the period of spawning and egg incubation (December to March). In any controlled site there is the danger, in the long term, of severe drawdown for maintenance during periods of peak use. The probability of low levels during summer droughts (which may lead to unsuitably high temperatures for vendace and loss of their deep-water refuge) must also be determined in each case. In general, public water-supply reservoirs are considered favourably for fish conservation introductions, not least because they are usually artificial and therefore natural ecosystems are not affected. Conversely, hydro-electric reservoirs are not so favoured since during the winter egg-incubation period, electricity...
demand is high and rapidly fluctuating water levels are common.

j) Enrichment. Considering the problems experienced by vendace in Mill Loch, Castle Loch and Bassenthwaite Lake, which are to a significant extent attributed to enrichment effects, sites known to be eutrophic or with elevated trophic status are not considered suitable for vendace translocations. Such sites are usually found at lower altitudes, near to urban areas or in areas where farming is a major land use.

k) Security. Site security is important and generally involves ease of public access and recreational or commercial use. Risks from pollution, casual introductions of undesirable fish species and general disturbance are matters of concern. Therefore, sites in or adjacent to urban development are not considered suitable.

In addition to identifying receptor sites for the establishment of permanent conservation introductions, other water bodies that offered potential as ‘holding sites’ (for growing on juvenile vendace to adults, which could then be translocated or stripped) were also examined. Reproduction is not a necessity at these sites and the absence of suitable spawning substrate is not a major concern, so this expanded the range of sites available. The key selection criteria for a holding site were to have:

a) A manageable size of a few to several hectares so that retrieval of fish for stripping in three to five years’ time can be achieved with reasonable effort. It must be capable of supporting an adult population of at least several hundred vendace.

b) Preferably a simple basin form with no obstructions or restrictions to netting.

c) A depth of at least 3 m, but preferably 5 m, to give the fish some refuge from heat stress and predators.

d) Security from factors such as disturbance, pollution, recreation and poaching.

e) No formal angling and stocking interest.

f) No commercial or industrial interference.

g) Good water quality – equal at least to a SEPA classification of good ecological status.

h) Low numbers of other fish species.

i) Reasonable access.

Adams et al. (2014) reviewed the receptor site selection process for rare fish translocations within Scotland, and provided details of all conservation translocations that have taken place in recent decades. The conservation issues that affect, or have the potential to affect, vendace within the UK were reviewed by Winfield et al. (2012).

Obtaining vendace for translocation

Vendace populations, like those of many other lacustrine (lake dwelling) fish species, have been separated from each other since the end of the last ice age around 10,000-13,000 years ago. These populations are likely to have been genetically isolated and it is unlikely that additional genetic material has been introduced. They may also differ phenotypically, as well as genetically, and as such they should be treated as separate ‘conservation units’.

The removal of large numbers of adult fish from an existing population, which may itself be regarded as being vulnerable, to establish a new population, may not be viewed as acceptable. Consequently the translocation of fertilised eggs (or larvae/fry derived from them) from donor sites is considered to be more acceptable.

Considerable thought has to be given, therefore, to how reproductive material is collected from male and female fish in the donor population. This should be done in a way that represents the genetic variability within the donor population, keeps mortality to a minimum and maximises the chance of survival of any progeny produced.

One of the first actions carried out as part of the 2007-12 work project was to collect further material for establishing vendace in the sites identified as possible receptors. In December 2007 nets of appropriate mesh sizes were set in Derwent Water to catch spawning vendace. Eggs collected there were fertilised on site (Fig. 3) and taken to a hatchery set up for this purpose at Barony College, Dumfries. This work was carried out in conjunction with the Environment Agency. The number of fish captured during this exercise was much lower than anticipated and only 13 were stripped and 3,600 fertile eggs were available for translocation.
The small numbers of adults collected, together with the low number of eggs fertilised and limited scope for replicating the genetic diversity that may exist within Derwent Water vendace, meant that the risk associated with using this material to establish a new population was too high. It was decided that the most appropriate course of action was to use this material to supplement earlier vendace conservation introductions to Daer Reservoir, and leave three other possible receptor sites (Black Esk Reservoir and Lochs Valley and Trool) for future use. Further detail on the collection of broodstock, hatchery procedures and fish release are provided in Lyle and Maitland (2011).

**Genetic analysis**

Only a few population genetic studies using allozyme and mitochondrial DNA markers have been carried out on British coregonids (the family to which vendace and other whitefish species belong). These have provided only limited insights into the higher order taxonomic relationships between vendace and the only other extant whitefish species present within mainland Britain, *C. lavaretus*. Locally *C. lavaretus* is known as powan in Scotland, schelly in England and gwyniad in Wales, and although it has been suggested that these are separate species, SAF-funded research has demonstrated that they are all the same species (Etheridge et al., 2012a).

Until recently, little was known about the nature and extent of coregonid population structuring both between, and within, water bodies. Recent work (Etheridge et al., 2012b; Adams et al., 2016) using material from British coregonid populations has shown that such structuring does exist. One aim of this element of the SAF project was to identify those microsatellite DNA markers, currently exploited in other salmonids, that would be suitable for the genetic characterisation of the two British coregonid species (vendace and powan). A further aim was to carry out an analysis of genetic variation within and between coregonid stocks from the two water bodies – Derwent Water and Loch Skeen – where vendace was known to be present. It was also hoped that these molecular markers could be used to assess and monitor the effective breeding sizes of these populations.

A key finding from this work, carried out by Marine Scotland Science, was that standard salmonid DNA extraction methods were unsuitable for polymerase chain reaction (PCR) amplification of coregonid DNA isolated from the samples. PCR amplification is a process where small, specific segments of DNA are amplified across several orders of magnitude to allow the identification of species. It was thought that the unsuitability of standard methods for extracting salmonid DNA was due to problems with the breakdown of DNA and the likely presence of PCR inhibitors, although these problems could to a large extent (but not completely) be overcome by using more expensive commercial DNA extraction kits. The problems were particularly acute for tissues taken from specimens stored frozen for months and then defrosted and, most likely, for netted fish that may have been dead for considerable periods before tissue sampling and storage in 100% ethanol.
More than 40 microsatellite markers developed for other salmonid species, including coregonids, were reviewed in relation to their potential for cross-species amplification. The 10 with the most potential for use on British coregonids were identified, although most of these either could not be amplified or could only be amplified inconsistently. This gave complex patterns that were difficult to type reliably, or showed little or no variation between individuals. Only three microsatellite markers were found to be potentially suitable for genetic screening. These were \textit{Bwf}1 and \textit{Bwf}2, previously identified in the broad whitefish (\textit{Coregonus nasus}) and \textit{C2-157}, identified in North American ciscoes (\textit{Coregonus spp.}), which showed a level of polymorphism comparable with other coregonid populations, with between four and seven alleles per locus.

Observed genotype proportions are significantly different between vendace samples from Derwent Water and Loch Skeen, confirming that maintaining a strategy of only introducing fish from one parental stock into a new refuge location (for example only stocking Loch Skeen with fish from Bassenthwaite Lake) is correct. This is particularly relevant if, at some stage, vendace from Loch Skeen are used to help support the recovery of this species in Bassenthwaite Lake.

\section*{Investigating food webs using stable isotopes}

Stable Isotope Analysis (SIA) has emerged as one of the primary means to analyse the structure of food webs (Layman \textit{et al.}, 2012) and is increasingly used by aquatic ecologists to understand the long-term diet and habitat use of consumers (Grey, 2006) (see box).

Analysis of stable isotope ratios in Loch Skeen (Harrod, 2011), revealed that the different fish species were largely distinct isotopically. Vendace showed little overlap with brown trout and no overlap with minnow. Brown trout displayed

\section*{Stable Isotope Analysis (SIA)}

Many chemical elements, including carbon and nitrogen, have more than one stable isotope. For example most carbon is present naturally as $^{12}\text{C}$, with approximately 1\% being $^{13}\text{C}$. The ratio of the two isotopes may be altered by biological and geophysical processes. Stable isotope compositions are expressed in terms of delta values ($\delta$) as parts per thousand (‰) differences from a standard.

The ratio of $^{15}\text{N}$ to $^{14}\text{N}$ (expressed relative to a standard, $\delta^{15}\text{N}$) exhibits stepwise enrichment with trophic transfers, and can be used to estimate the trophic position of organisms. By contrast, ratios of carbon isotopes ($\delta^{13}\text{C}$) can vary significantly among primary producers with different photosynthetic pathways, but change little with trophic transfers. Therefore, $\delta^{13}\text{C}$ can be used to determine original sources of dietary carbon.

As different primary producers, such as phytoplankton and littoral epilithic algae, have distinct carbon stable isotope ($\delta^{13}\text{C}$) values, and consumer $\delta^{13}\text{C}$ values are typically close (within ca. 1‰) to those of their prey (Post, 2002), the technique allows the long-term foraging patterns of mobile consumers such as fish to be estimated. Nitrogen stable isotope values ($\delta^{15}\text{N}$) for consumers tend to be ca. 3.5‰ higher than those of their long-term assimilated diet (Post, 2002). Hence, if the $\delta^{15}\text{N}$ value of the primary producer or primary consumer is known, the trophic level of a consumer can be calculated. By comparing the stable isotope ratios of different consumers and their putative prey, a food web can be rapidly generated, allowing key trophic resources and potential dietary overlap between individuals and species to be identified.

A major advantage of SIA over traditional methods of estimating diet (such as stomach or gut contents analysis (GCA)) is that it reveals long-term assimilation patterns and also allows information to be gathered from individuals with empty stomachs. By combining SIA data with data from individual fish (such as size or age) it is possible to examine intraspecific variation in assimilation patterns or habitat use (Harrod \textit{et al.}, 2005; Harrod and Grey, 2006).
considerable variation at the individual level, with isotopic differences between individuals from offshore and inshore habitats. Brown trout showed an increase in trophic level ($\delta^{15}N$) as they grew, but there was no isotopic evidence that brown trout were consuming vendace in Loch Skeen. An attempt was made to carry out similar work in Loch Earn (Harrod, 2011; Maitland et al., 2011), where a single specimen of vendace, possibly arising from a translocation event in 1989, was captured by an angler in 2005. If vendace were present and well established, it would be important to determine whether there is any trophic overlap between vendace and Arctic charr. Unfortunately, despite extensive sampling in 2007, no additional vendace were obtained.

**Going beyond the Translocation Guidelines - new habitat assessment techniques**

During the tenure of the SAF project, translocation guidelines (IUCN, 1998; JNCC, 2003) were used to identify the most appropriate receptor sites for vendace, and other freshwater fish translocations in Scotland.

One of the aims of this SAF project was to inform the receptor site selection process for vendace by developing a video-based classification system for vendace spawning substrate (Fig. 5), and applying it to sites that already host populations of vendace, and sites that are being considered for the establishment of new populations. The Scottish sites included in this work were Daer Reservoir, Loch Skeen, Black Loch (Galloway), Loch Valley, Mill Loch and Loch Earn. Surveys of the last two remaining ‘natural’ vendace sites in the UK, Derwent Water and Bassenthwaite Lake, were also carried out (Coyle and Adams, 2011). Assessments were made by characterising known or potential spawning grounds as ‘optimal’, ‘sub-optimal’ and ‘poor quality’ spawning substrates, using a combination of shallow-water habitat assessment and deep-water transects.

Successful breeding by vendace is very dependent upon high-quality spawning habitat. For example, the natal homing of the fish may be disrupted if the character of the spawning ground is changed (such as being covered by silt, algae or macrophytes). Declining quality of spawning habitat has been implicated in the loss or decline of at least one vendace population (Bassenthwaite Lake) and change in the quality of spawning sites in other standing waters is one of the key factors that may affect long-term population survival. In addition, spawning site quality and abundance are very important when identifying new sites for future translocations.

The surveys concluded that Derwent Water, Loch Earn and Daer Reservoir had the highest quantity of optimal quality spawning substrate (36.5%, 32.7% and 32.5% respectively). Conversely, Black Loch and Mill Loch had the highest proportion (100%) of poor quality spawning substrate. Despite having a healthy vendace population, Loch Skeen contained mostly sub-optimal spawning substrate. The condition and extent of spawning substrate in Loch Valley, a potential site for vendace translocation, was also considered to be sub-optimal. Of particular interest was that Bassenthwaite Lake, a site containing a ‘natural’ population of vendace, was almost devoid of optimal quality vendace spawning substrate. This supports the view that the paucity of good quality spawning substrate may be one of the main contributing factors in the decline of vendace at this site.
Assessing population size at Loch Skeen

Sampling at Loch Skeen by gill-netting in 2003, as part of the UKBAP Species Action Plan work (Maitland et al., 2003), found that the translocation of vendace from Bassenthwaite Lake had been successful and that a reproducing population had been established. However, a full population study, including an assessment of abundance, was not undertaken at that time. The objective of this element of the SAF project was to apply a Site Condition Monitoring assessment protocol, developed for a closely related coregonid species (powan), to the vendace refuge population of Loch Skeen (Fig. 6). This involved the use of quantitative hydroacoustics and a targeted gill-netting survey followed by assessment of results against a series of criteria covering abundance, population demographic structure, and maintenance of habitat quality.

This survey (Winfield et al., 2011) showed that vendace recruitment was evident for all years, and that fish ranged in age from one to six years. The geometric mean abundance of vendace was 231.7 fish per ha, and the mean percentage contribution by small individuals to the combined offshore populations (identification to species was not possible) was 81%. This suggests that overall levels of recruitment within the population are high, and that the population is now self-sustaining.

Lessons Learnt, Further Work and Future Recommendations

Partnership working

By working in close collaboration with others the lead partner was able to co-ordinate a number of complex and specialised work areas. These included the development of population assessment protocols using state-of-the-art hydroacoustics and underwater (ROV) video assessments, and genetic and stable isotope analyses.

The success of the partnership was ultimately the result of mutual trust between SNH as lead partner and the other project partners. The advantage of partnership working is the pooling of physical and intellectual resources. Financial constraints continue to be a problem for projects such as this where long-term funding is required to monitor the success, or otherwise, of translocation attempts. Following the introduction of new material, sampling to assess recruitment success may not be possible for up to three years. Even with a life span of five years, the period covered by the SAF project was not long enough to allow a full assessment of its success for this species. Other constraints, such as different national attitudes to the use of gill-nets for the capture of broodstock, or to carry out population assessments, can limit availability to material and monitoring data.

Managing expectations - the long game

The success or otherwise of any conservation translocation exercise may not be apparent for several years after the initial release. The key issue leading on from SAF is the availability of resources to monitor the success of translocations made during the SAF project, and the continuation of the translocation programme should these introductions be unsuccessful. We would recommend that funding be made available to continue the monitoring programme, in order to ascertain whether the actions taken during the SAF project have been successful, whether the translocation of vendace to new locations results in morphological change to the species in that environment, and to maintain oversight of the health of these populations. For the last of these, it may be possible to supplement monitoring effort with

Fig 6. Non-invasive hydroacoustic techniques were used to assess the success of the vendace conservation introduction in Loch Skeen (Dumfriesshire) and Daer Reservoir (South Lanarkshire).
new advances in environmental DNA technology. However, the need for periodic, low intensity, physical sampling will remain.

Conclusions

- Vendace is the rarest freshwater fish in the UK. While this species is widespread in northern Europe it is at the extreme edge of its western range.
- Its Arctic affinities mean that this species may be especially vulnerable to the effects of climate change. This has implications for the protection of existing populations, but also has implications for selecting new translocation receptor sites.
- Invasive species and eutrophication, in addition to climate change, are key threats both to existing and new refuge populations of vendace, and appropriate safeguards must be put in place to protect these vulnerable populations.
- Experience of applying site selection criteria described in the IUCN Translocation Guidelines (and those contained in the more recent Scottish Code for Conservation Translocations (NSRF, 2014)), to identify new receptor locations for vendace introductions, suggests that options for new sites may be limited to artificial water bodies or those recovering from acidification. Work carried out during SAF added to our
understanding of spawning habitats for vendace and their distribution within existing donor and receptor sites.

- Conservation translocations require long-term funding and monitoring commitments if their success is to be assessed properly. The successful establishment of vendace in Loch Skeen provides confidence that new sites for this species can be established. The introduction of vendace to other sites (Daer Reservoir and Loch Valley) requires further evaluation. The expanded range of vendace, as a species listed in Annex II of the Habitats Directive, may be included within future Article 17 reporting obligations, so a commitment to continuing monitoring existing and future populations may be required.

Further Information


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The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

White-tailed Eagle

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**Summary**

- The Species Action Framework (SAF) part-funded the initial translocation and release of young white-tailed eagles (sea eagles) in the east of Scotland, as part of the overall reintroduction to Scotland of this species which started in the 1970s.

- Through a partnership of Scottish Natural Heritage (SNH), Royal Society for the Protection of Birds (RSPB) Scotland and Forestry Commission Scotland (FCS), the East Scotland Sea Eagle Project (ESSE) released 85 birds between 2007 and 2012.

- The ESSE project aims to help recover the historical range in Scotland and to found an additional population away from the west coast.

- Restoring a large predator such as white-tailed eagle is a long-term project and requires continuing management and monitoring to ensure success.

**Introduction**

**Species background**

This section draws on the following key references: Love (1983, 2007). The white-tailed eagle (*Haliaeetus albicilla*), also known as the sea eagle, is a native species to Scotland. However, by the early 20th century it had become extinct through persecution, primarily owing to the belief that it was a major predator of livestock and game.

Across Europe the species was also in decline and it became a very rare visitor to Scotland with little prospect of natural recolonisation. Two independent releases, each of four birds, at Loch Etive, Argyll in 1959 and on Fair Isle, Shetland in 1968, initiated thoughts of a more formal reintroduction. In the early 1970s the Nature Conservancy Council decided to undertake a sustained chick release programme. From 1975 to 1985, 82 eaglets from Norway were released on Rum National Nature Reserve. This release established territorial pairs on several west coast islands with the first successful breeding occurring on Mull in 1985. This initial population relied on a few consistently successful pairs and there were concerns about the long-term viability of the population. A second phase of releases was agreed to bolster the population. From 1993 to 1998 a further 58 eaglets from Norway were released in Wester Ross under a joint SNH and RSPB project. This release, combined with the increasing number of wild-bred young entering the population, had allowed the west coast breeding population to reach 42 pairs by 2007 when the third phase of releases in the east of Scotland commenced.

**Why was this species on the Species Action Framework list?**

The white-tailed eagle was an obvious candidate for inclusion under the SAF as a species for conservation action, as there was already a reintroduction programme underway. At the time of the SAF starting, consideration was being given by the Sea Eagle Project Team (now White-tailed Eagle Project Team) to a third phase of releases away from the west coast in order to enhance recovery of historical range, and to establish a second population to ensure a successful reintroduction. This resulted in SAF funding supporting the ESSE project, under which translocated eaglets from Norway were released in Fife.

**Habitat, distribution and abundance**

The species is widespread across much of northern Eurasia, breeding from Greenland east to Japan, and south into south-east Europe, the Middle East and central Asia (see white-tailed eagle factsheet for more information on population size and distribution). When the Scottish reintroduction started in the 1970s the species was listed as being Near-Threatened by IUCN, however conservation efforts across its range lead to its status being revised to Least Concern in 2006.

As indicated by its large geographical range the species occupies a wide range of habitats. There is an association with coastal and freshwater habitats in both lowland and upland situations. It is also found in both open and wooded or forest habitats. In many areas where its abundance is relatively high it lives close to human populations including winter roosts and nesting pairs near large towns and cities. The species is also adapted to a wide range of climatic conditions, again evidenced by its broad distribution, though some northern populations are migratory.
General ecology

In Scotland comparison is often made with the golden eagle (Aquila chrysaetos), however the white-tailed eagle has significant differences in its ecology and several studies in Scotland indicate that there is minimal competition between the two species (Evans et al., 2010; Whitfield et al., 2013). White-tailed eagles as adult pairs can be less territorial and can nest at fairly high densities more often than golden eagles. This more social behaviour extends to the immature birds too. As with other large raptors, young white-tailed eagles take around five to six years to reach breeding age. During this period they range widely but also form non-breeding communal roosts. These roosts may have an important role in pair formation amongst older immature birds in particular.

The species has a relatively long breeding season, laying eggs during March and April, with young leaving the nest usually in July and August. Adult pairs generally remain on territory all year, roosting at or near the nest although they will at times join nearby communal roosts too.

Nest sites in Scotland are usually in trees or on cliffs and crags. Some of the latter sites are almost ground nests whilst a range of tree species are used, though most are in conifers. The main requirements for tree nests are that the tree can support the large stick-nest and has limited exposure to adverse weather.

The diet of the species is wide, including both live prey and carrion. They generally take a greater proportion of waterbird and seabird prey compared to golden eagles (Whitfield et al., 2013). Most prey consist of medium-sized mammals (e.g. rabbits and hares) and birds (e.g. gulls, ducks, geese, auks, grouse and, especially in Scottish coastal sites, fulmar). In some parts of their world range they eat mainly fish. In Scotland fish form a smaller component of the diet although over 20 species have been recorded in the diet of the reintroduced population (Marquiss et al., 2004). Most carrion consumed in Scotland is deer or sheep.

History of decline, contributory factors and current threats

The species became extinct in Scotland in 1918 following a decline which was largely attributed to persecution. The species was considered a serious predator of livestock especially sheep and was heavily persecuted in the 19th and early 20th centuries, with specimen and egg collectors also contributing to the eventual extinction as the species became rarer.

Prior to the reintroduction starting in the 1970s, consideration was given to how viable it would be. The factors that contributed to the decline were considered before it went ahead and the detailed monitoring of the population since reintroduction has helped identify and manage threats and risks to the species. The main threats historically of persecution and egg collection though still present today have declined in importance. The first nesting pairs in the west were very intensively monitored with volunteer nest-watches to try to prevent interference with the birds. These were successful and fundamental in allowing the population to become established.

The perception of white-tailed eagles as predators of lambs still prevails, and has been a difficult one to deal with at times. SNH has responded to concerns from the farming community and their representative bodies about alleged lamb predation throughout the reintroduction. Two studies for SNH into lamb predation, one on the island of Mull where white-tailed eagles first bred, and a later one at Gairloch in Wester Ross, identified that the eagles do take a small number of live lambs, but the majority of lambs taken were scavenged as carrion (Marquiss et al., 2004; Simms et al., 2010). As result of this research, a Sea Eagle Management Scheme has been established by SNH to help those farmers and crofters at risk of losing some lambs from eagle predation. Funding is available to both help improve lamb and sheep flock health and to undertake preventative measures so they are less likely to be impacted by eagles, rather than to compensate for losses. This has helped allay the concerns of some but not all.

White-tailed eagles continue to be persecuted in Scotland, as a number of reintroduced eagles are known to have been killed illegally or to have disappeared in suspicious circumstances inferring illegal killing. Whilst these losses may have had some influence on the establishment and growth of the population, they have not been at a level that has hampered the re-establishment of the species.

A newer potential threat is from wind farms, as information from Scandinavia and continental Europe has shown that white-tailed eagles are relatively poor at avoiding turbines and so are at risk of collision (May et al., 2010; Dürr, 2015). In Scotland, to date, risks to white-tailed eagles have been minimised through discouraging developments in key areas. Both persecution and wind farm collision risk are of most concern where...
they may affect new ‘pioneering’ pairs outside the main range, as loss of these pairs could impact on range recovery. Disturbance of nesting pairs and of regular roosts can also be an issue, and guidance has been drawn up by Forestry Commission Scotland to help minimise the effect of operations on white-tailed eagle roost and nest sites in commercial forests. This guidance can also be applied to a wide range of activities that occur outwith forestry (see Further Information).

Aims

Aims for 2007-2012

• To translocate and successfully release 15-20 white-tailed eagles per annum to the Tay/Forth area between 2007 and 2012.
• To monitor released birds as they establish territorial and ultimately nesting pairs.

The aim post-2012 has been:
• To augment the range expansion of the west coast population of white-tailed eagles by establishing a viable, self-sustaining breeding population in the east of Scotland.

Management Action

Summary of the main action undertaken

• A partnership was formed between RSPB Scotland, SNH and FCS, with RSPB Scotland and SNH jointly funding the project between 2007 and 2012. RSPB Scotland employed a project officer, and FCS provided the release site. Through this partnership, the East Scotland Sea Eagle (ESSE) project steering group was also formed.
• Appropriate assessments were made and the necessary parties consulted.
• Donor stock was identified in Norway and agreement made with Norwegian Birdlife partner Norsk Ornitologisk Forening (NOF). Over 200 eyries were monitored annually by NOF in three counties to allow enough donor chicks to be identified and collected.
• A release site was secured and holding aviaries constructed.
• Young eagles were translocated in June and released in August each year from 2007 to 2012. Eighty-five birds were released in total.

Planning

The decision to continue with the third phase of reintroduction to Scotland was made by the Sea Eagle Project Team in 2003. Research concluded that 85-100 white-tailed eagle chicks would be necessary to establish a new breeding population in eastern Scotland.

A feasibility study and habitat assessments were carried out for several suitable geographical areas in Scotland for the reintroduction site prior to the final site selection. The project was fully considered against IUCN guidelines (IUCN, 1998).

Once the final release site had been chosen RSPB Scotland staff, on behalf of the ESSE project steering group, also liaised with potential stakeholders and public bodies that may be affected by the reintroduction, including the bodies representing landowners, agricultural interests and elected representatives.

In June 2007, the then Minister for Environment, Michael Russell MSP, approved the licence for the reintroduction programme.

Location of work

Although other areas were considered, the Tay/Forth estuary area was concluded as being the most suitable location for the third phase of the reintroduction. It provided the largest estuary area and much high quality habitat for feeding and nesting. This area also had a relatively low incidence and risk of illegal persecution of birds of prey, and minimal potential conflict with sheep farming, compared to other sites considered. Additionally, though not part of the formal assessment, a high proportion of Scotland’s people live close by, providing opportunities to encounter the birds with substantial educational and eco-tourism potential. FCS provided a suitable secure aviary site at Weddersbie Forest, a quiet and relatively isolated woodland with minimal recreational or operational disturbance. The site
was kept secret, though regular users knew and respected its sensitivities. This also gave the local community a sense of ownership and acted as a security measure in itself.

The aviaries were monitored using CCTV cameras with images sent to a device monitored by the project officer. Local landowners were positive and cooperative, and a local farmer assisted with access and allowed project staff to store food for the captive eagles. Fife Police checked the site regularly.

**Methods and techniques**

A donor stock of young white-tailed eagles was identified through the Norwegian Sea Eagle Project. Licences were granted for chicks to be collected in three counties: Møre & Romsdal, Hordaland and Sogn & Fjordane.

Licences required for the exportation, import, holding and release of the birds were necessary under CITES (for export and import), Animal Health legislation, and the Wildlife and Countryside Act 1981. A project officer was employed in April 2007 prior to the first cohort of white-tailed eagles being collected.

Aviaries were designed and constructed with an artificial nest platform, perches, and a large release hatch in the front with thick, double layer mesh (Fig. 1). A door and feeding hatch were located in the back of the aviary allowing staff to feed the birds without unnecessary contact. Nest platforms were 1 m above the ground and lined with untreated tree bark and a layer of sphagnum moss.

Staff from the Norwegian Sea Eagle Project monitored active sites in January to identify potential donor nests in June. Chicks were collected only from nests containing twins or triplets, at the age of 5-8 weeks, when they were old enough to regulate their own body temperature and feed themselves unassisted by parent birds, but small enough not to abandon the nest.

Prior to export, the chicks were checked by vets to ensure that they were fit to be transported. This also satisfied the requirements of the CITES export and import licences, and the Animal Health import licence.

In 2007, the Royal Norwegian Air Force transported the chicks to RAF Kinloss. In subsequent years, an aircraft was chartered to transport the chicks to Edinburgh airport. After the relevant customs procedures and paperwork had been processed airside, the chicks were transferred in vehicles to the aviaries.

On arrival at the aviaries, health screening was carried out in conjunction with Natural Research Ltd (NR) and the Exotic Animal and Wildlife Service (EAWS) of the University of Edinburgh’s veterinary school. Full haematological and biochemical analyses were carried out, and samples taken to monitor lead levels, faecal parasites and faecal bacterial cultures. Blood smears were also taken for haemoparasite analyses and blood plasma was stored for further analyses. All birds were sexed by NR using DNA from blood samples. Chicks were weighed and biometric measurements taken. The chicks were then housed in pairs and matched as closely as possible according to size to prevent competition and exclusion for food.

The chicks were fed twice a day initially, on a varied diet of fish, rabbit, venison and grey squirrel. All the food was donated by FCS, local game dealers, fish shops, and the Scottish Wildlife Trust who provided culled grey squirrels. The chicks were medicated to prevent the potential development of stress-related illnesses for the first five days in captivity, and vitamin and mineral supplements were added to their food throughout the captive period. Feeds were reduced to once a day as the birds grew and were able to tear apart larger prey.

The chicks were kept in captivity for 7–8 weeks and released when they were roughly 14 weeks old to coincide with when they would naturally fledge the nest. A week prior to release, all chicks were re-sampled for health parameters and given a welfare check by vets. Wing and tail-feather
growth was checked and full biometrics taken again. Every chick was fitted with tags on each wing to enable identification and ageing of birds in the field (Fig. 2). Different colours were used each year with a single letter or number legend. Due to a change in the licensing procedure, wing tags were not fitted in 2008. The chicks were also fitted with 70 g Biotrack VHF transmitter backpacks using a Teflon harness authorised by BTO (Fig. 2). Each bird had a unique frequency so that dispersal could be monitored. The VHF transmitters have a mortality setting which is triggered if a bird is stationary for more than 6 hours, allowing the retrieval of any dead birds for post-mortem examination.

Fig 3. A young white-tailed eagle being released in August 2010.  
© Andy Hay/RSPB Images

During the winter months, the project officer gave talks to local interest groups and attended events to raise awareness of the project, and to engage with the community close to the release site and beyond.

In 2010 a part-time education officer was employed to deliver a programme for primary schools in Tayside and Fife, to engage local children in the project and wider conservation. Resources were created for teachers and information was shared on the Scottish schools intranet ‘Glow’. Links with schools in Norway were also encouraged. Volunteer field teachers also played a key role in successfully delivering this programme.

Problems and solutions
Since the first release in 2007, there have been 14 reported incidents of released white-tailed eagles predating on domestic poultry and wildfowl, and five cases of game bird predation, varying in severity. All cases involved juvenile birds, and occurred up to eight weeks after release. Two incidents of white-tailed eagles scavenging lamb carcasses occurred, but the lambs were already dead. Every incident was followed up immediately by the project officer and measures were taken to prevent further incident through positive management. This was done with advice and collaboration with SNH area officers.

Each year during the project there were also several cases of mortality (see Fig. 4). A protocol for retrieving carcasses and appropriate post mortem or toxicology was agreed between EAWS and NR, RSPB Scotland, Tayside and Fife Wildlife Crime Officers, Science and Advice for Scottish Agriculture (SASA) and Scotland’s Rural College (SRUC).
Mortality of released birds was caused by collisions with wires/electrocution, collisions with trains and persecution, and one bird was euthanized after being found with severe injuries from being struck by a seal on the Isle of May. In 2014, a three year old male was killed by a wind turbine in the Ochil Hills, Clackmannanshire. Dead birds were detected through radio-tracking or reported by members of the public. The majority of fatalities were juveniles and occurred between the release period and their first winter.

Young birds were occasionally found unwell or injured and in need of rehabilitation, which was undertaken by Alistair Lawrie and the Scottish Society for the Prevention of Cruelty to Animals (SSPCA) before re-release.

During the first two years of the project, some of the VHF transmitters failed to work. Monitoring of these individuals was therefore difficult, but still possible through observation of wing tags.

Through the media, critics of the project questioned the viability of the reintroduction. Some doubted the suitability of the Scottish climate, claiming that it is too wet for white-tailed eagles. However, the survival rates of the released birds are similar to those of previous Scottish releases and some wild populations elsewhere (Evans et al., 2009). Others assumed that the birds were tame due to the belief that they had been imprinted during their time in captivity. However, considerable care was taken to avoid human contact before birds were released and this species appears more naturally ‘tolerant’ of human activities than other large raptors.

Partnership working and resourcing

The ESSE project was managed via regular Steering Group meetings throughout the project. Regular reports were made to the Scottish Government. As well as supporting the project financially, SNH also assisted with licensing and assessed reported livestock incidents. Additional funding for the final year of releases in 2012 came from Heritage Lottery Fund (HLF) and Rural Tayside and Fife LEADER.

Volunteers played a key role with activities such as feeding birds in captivity, stocking the food dump, post-release monitoring of the birds and data entry. One volunteer used her expertise to make a short documentary about the project for schools. Outwith the area covered by radio-tracking, sightings from the public provided invaluable information about the birds’ dispersal.

Results

Between 2007 and 2012, 85 birds were released into the wild in Fife. The overall survival rate of the released birds to the end of 2014 was 69% with 27 carcasses recovered. This was comparable to the mortality rate seen in the west coast-released population. Fig. 4 summarises the survival statistics for 2007–2014.

Fig. 5 shows the dispersal of east coast-released white-tailed eagles and indicates where most birds have spent their time.

![Fig 4. Summary of survival and causes of mortality of white-tailed eagles released in the east of Scotland between 2007 and 2012, as of December 2014.](image)
Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

The east coast project has built on west coast experience of rearing and releasing. The design of the release aviaries was based on those used during the successful second phase of releases in Wester Ross, and previous red kite releases in Scotland.

The east coast project also had the advantage of monitoring all birds using radio-telemetry. This gave information on dispersal and survival. Better technology, such as satellite tags, has provided more accurate information about bird movements and roost sites and allows rapid mortality detection, though at much greater cost.

Due to the location of the release site, the east coast project had the benefit of more accessible expert veterinary care than the more remote west coast releases. Welfare techniques have also improved since the initial release on Rum and the methods that are now used minimise human contact as much as possible.

As the first nesting attempts of the east coast-released birds occur, there will be careful management of the threats outlined previously and of land management activities close to nests to ensure the success of their establishment in the east of Scotland. Constructive engagement with the relevant stakeholders will be essential to achieve this.

The value of volunteers, stakeholder engagement and the help of the public in providing sightings of the birds has been immense. Without these, the project would not have been a success.

The project was fortunate in securing a release site in FCS woodland with a cooperative neighbouring farmer and community. The farmer lent his support throughout. The support from the local community has been paramount to the security at the release site, with several members reporting sightings of the newly released birds.

Overall, the east coast white-tailed eagle project highlighted the need for careful planning, and for strong representation from Scottish and international project partners to overcome management issues and potential criticism.
Future recommendations

- The methods and techniques for releasing birds used during this project have been successful, and therefore could be considered for similar projects elsewhere with the provision that local conditions are taken into account.
- The consultation process should be thorough, and ensuing monitoring should meet strict IUCN guidelines on reintroductions, especially in a densely populated area where the risk to the reintroduced population may be greater.
- Strong partnerships are essential. Planning and preparation should be thorough, and communication should be maintained with partners and wider stakeholders throughout.
- A contingency should be put in place for scenarios such as wildlife crime incidents, livestock predation, and conflict with land management activities. Positive management solutions should be offered as a proactive measure as well as preparing for a reactive and sympathetic response.

New and ongoing work since SAF ended

- Since the SAF project funding came to an end in 2011, the partnership between RSPB Scotland, SNH and FCS has remained. Funding was secured from HLF and Leader for a further year of translocation, allowing six more birds to be released.
- Steering group meetings continued beyond the translocation phase of the project to address further management issues involving the released birds and establishing pairs. A volunteer network has been formed to help monitor these new pairs and to help protect nesting attempts.
- Monitoring of the released birds continued in accordance with IUCN guidelines through a programme of radio-tracking. A database to record all contact with the released birds, and for future analysis of dispersal, is still maintained.
- In 2013 the first pair of released birds from the east coast project bred successfully in Fife, with four pairs established in the east by 2014. Other east coast pairs have established and some individuals have successfully bred with wild-fledged west coast birds. The overall Scottish population had increased to 98 pairs in 2014.

Further Information


References


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The SAF Partners

- Scottish Natural Heritage
- RSPB Scotland
- Forestry Commission Scotland

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

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Freshwater Pearl Mussel

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Summary

- Conservation status – The freshwater pearl mussel is a critically endangered mollusc and some of the largest remaining populations live in Scotland. It is extremely vulnerable to pollution, river engineering, persecution and changes in host salmon and trout numbers.

- Genetic diversity – the Species Action Framework (SAF) project helped fund the first survey of freshwater pearl mussel genetic diversity across Great Britain. This found that after the last glaciation it appears that freshwater pearl mussels dispersed from two distinct refugia.

- Reintroduction – Freshwater pearl mussels were reintroduced to a river from which they had become extinct and, since then, the reintroduced animals have successfully reproduced.

- Restoration – the SAF project helped fund the development of catchment-scale restoration plans. These are now being implemented as part of an exciting EC funded project, Pearls in Peril.

- Wildlife crime – Scotland is unusual in being the only country where there is a serious continuing threat from illegal pearl fishing. The SAF partnership helped raise awareness of the threat by contributing to a significant police operation.

Introduction

The freshwater pearl mussel (Margaritifera margaritifera) is a large, long-lived, bivalve mollusc of rivers and streams. Scotland is a stronghold for this species, having several of the world’s largest known recruiting populations. However, the numbers of populations have declined substantially in the last 100 years owing to human activities. Although the species is now considered to be ‘critically endangered’ (Cosgrove et al., 2000; Cuttelod et al., 2011) there are a number of management actions that can be employed which should help to turn around this decline.

Extensive programmes of survey and research have been undertaken on the species in Scotland, so there is a good knowledge base (e.g. Skinner et al., 2003). A wide range of other species will benefit from management targeted at the pearl mussel because it requires high quality riverine habitat. Management measures aimed at enhancing native salmonid fish stocks are also important as these fish are an essential link in the pearl mussel life cycle.

As well as being included in the SAF project, it was listed as a UK Biodiversity Action Plan (BAP) Priority Species and is included on the Scottish Biodiversity List. It is listed on Annexes II and V of the EC Habitats Directive and is fully protected under the Wildlife and Countryside Act 1981, as amended.

The freshwater pearl mussel inhabits coarse sand and gravel beds of fast-flowing, non-calcareous streams and rivers (Fig. 1). There are approximately 72 recruiting or ‘viable’ populations (i.e. with juveniles present) in Scotland, mostly in the north and west, with scattered records of the species elsewhere. Few viable populations occur elsewhere in Britain.

Fig 1. Freshwater pearl mussels living in the gravel and sand patches between rocks on the bed of a Scottish river.
© SNH

The pearl mussel feeds by filtering out fine organic debris in river water. Growth is slow. Pearl mussels do not reach reproductive maturity until at least 12 years old, with some animals living for well over 100 years. Mussel larvae (glochidia) are released by the females in summer and a small proportion of these attach themselves to the gills of young trout or salmon, where they live harmlessly before dropping off and settling on the river bed the following spring.

In approximately two-thirds of Scottish rivers occupied 100 years ago the pearl mussel is now extinct, or there is no evidence of recent juvenile recruitment (Cosgrove et al., 2000). Most of the remaining populations have also suffered substantial declines as a result of pearl fishing, pollution, habitat loss, and salmonid declines.
Despite recent legislation on pearl fishing, a range of pressures continue to operate, including:

- Habitat removal and alteration through development, drainage schemes, flow regulation and fisheries management.
- Declines in populations of salmon and trout, which act as the larval hosts.
- Destructive pearl fishing and illegal pearl trade.
- Poor water quality, including nutrient enrichment (which also affects the numbers of host fish).
- Conifer planting, which can release significant quantities of silt.
- Sedimentation from soil erosion, affecting the suitability of gravel and sand beds for juvenile mussels.
- Climate change, with increased spate events potentially destabilising the river bed and washing away pearl mussels.

**Aims**

**Aims and objectives for 2007-2012**

- To maintain or increase the size of all currently viable populations of freshwater pearl mussels.
- To re-establish four populations of freshwater pearl mussels.

**Management Action**

The management work was coordinated by SNH, in conjunction with a wide range of partner organisations who met as an overall steering group to agree how the overall objectives would be achieved. Partners contributed to individual projects financially and/or by providing advice or time to make sure that appropriate actions were taken. An example is the genetic research that was needed to inform the reintroduction of the freshwater pearl mussel. Fisheries Research Services (now Marine Scotland Science) provided facilities, the University of Aberdeen providing supervisory and advisory input, while SNH, the Environment Agency, Natural England and Countryside Commission for Wales provided the funding. Similar partnerships with other organisations funded and supported other actions.

We focused our effort in four main areas:

- The re-establishment of a freshwater pearl mussel population – more than 20 potential reintroduction sites were surveyed. We investigated the genetic diversity of pearl mussels across Great Britain for the first time and identified suitable donor populations. The first inter-catchment reintroduction of pearl mussels in the UK took place in 2010.
- Habitat restoration – our work included installing a fish pass to restore access for the pearl mussel’s host fish species in an important river. We also produced catchment-scale restoration plans for three large river systems, each with internationally significant pearl mussel populations. These are being implemented between 2013 and 2016. Advice was given to many landowners to improve land management around rivers with pearl mussel populations.
- Reducing wildlife crime – we helped raise awareness of illegal activity that damages pearl mussels, particularly pearl fishing, and improved the reporting and investigation of such crimes.
- Host fish – we investigated the status of the pearl mussel’s host fish species in many rivers for the first time. Those at greatest risk were identified and action is being taken to improve conditions.

**Re-establishment of freshwater pearl mussel**

In order to address the historic loss of freshwater pearl mussels from so many rivers in Scotland, the SAF project aimed to re-establish four such populations. This required careful planning and considerable preparatory work to identify suitable sites and to follow established guidance and criteria for undertaking species reintroductions.

The preparatory stages of this work involved identifying potentially suitable reintroduction sites and ‘donor’ populations.

Part of the process for planning a species reintroduction is to take genetic diversity into account (MacLean, 2003). To investigate this issue a project was started to determine the extent of genetic variation between and within a selection of populations. The outset of this work coincided with a desire to investigate the same issue in England and Wales, and therefore the project was extended to include those countries.
The survey involved extracting DNA from haemolymph from more than 1600 individual animals in 59 locations, and this was used to screen for genetic variation at nine microsatellite loci (Cauwelier et al., 2009). It was found that pearl mussel populations in Great Britain show a major evolutionary split into distinct northern and southern phylogenetic groups (Fig. 2), suggesting that British populations were established by post-glacial colonisation from two distinct refugial areas. The two phylogenetic groups should be considered as distinct evolutionarily significant units (ESUs) and translocations across these ESUs should be avoided. River populations within each of these ESUs should also be treated as single breeding populations, and translocation of mussels between populations should be avoided. However, translocations within most rivers can be reasonably considered to support conservation work. The study also found pearl mussel populations in Scotland to be genetically ‘healthier’ than those in England and Wales, most likely because most Scottish populations have not been as depleted.

To identify suitable locations for reintroductions to take place, a desk exercise identified potential historical sites where freshwater pearl mussels appeared to be extinct (Hastie, 2007). Of those watercourses identified, 28 were surveyed in 2007–2008 to establish if any extant pearl mussels remained and if conditions were still suitable for the species. The suitability of these candidate watercourses for mussel reintroduction was assessed using a model incorporating a number of key criteria that were developed and refined (Waterside Ecology/Cosgrove & Hastie Associates, 2009; Hastie et al., 2011). The criteria were:

1. Extent and quality of pearl mussel habitat.
2. Density of host juvenile salmonid populations.
4. Logistical access and availability of donor population.
5. Site security (i.e. risk of possible persecution).

The measure of habitat quality was not as sophisticated as originally hoped. The intention had been to use a relatively new technique of measuring redox potential within the river bed to determine the suitability of the river-bed habitat for freshwater pearl mussel (Geist and Auerswald, 2007). However, unreliable field equipment meant that this method could not be used and visual inspection and available water chemistry data were used instead.

Refreshingly, these surveys discovered remaining pearl mussel populations in six watercourses. Of the remaining watercourses, the analysis resulted in two rivers being selected for reintroduction in 2009. In one river (in Lochaber) adult pearl mussels were to be reintroduced and in another (in Dunbartonshire) pearl mussel larvae were to be collected and used to infect resident host fish. Unfortunately the latter reintroduction did not take place owing to problems of access. However, 200 adult mussels were moved from an identified donor population and translocated to the river in Lochaber in June 2009 (Fig. 3). Monitoring later that year and in 2010 confirmed that the reintroduction had been a success, with live pearl mussels still present in the river. Pearl mussel larvae were also recorded on the gills of juvenile salmon and trout in the river in both 2009 and 2010, indicating that the pearl mussels had successfully reproduced (Hastie et al., 2010). Further monitoring is planned for the future. It was unfortunate that only a single reintroduction took place during the SAF project. However, with other

We were able to use the results to identify potential donor populations for translocation that exhibited sufficient genetic diversity/variation and that were not unusually distinct from other local populations.
reintroductions (see below), there have now been three reintroductions in Scotland and important lessons have been learned.

**Fig 3. Freshwater pearl mussels being removed from a donor river for translocation in 2009. © SNH**

Despite being unable to reintroduce pearl mussels to the river in Dunbartonshire, a trial infection of host fish within a small area of the catchment where the donor population was located was carried out in 2009. This successfully demonstrated that the proposed technique was feasible. It was possible to monitor the development of pearl mussel larvae in the adult donor females, collect the larvae as they were released and then introduce them onto the gills of wild salmonids. This was done by careful monitoring of the adult female mussels in the weeks leading up to larval release. Larvae are usually released in July or August in Scottish rivers, and when it was judged that larval release was about to take place, the larvae were collected by placing female mussels in a bucket of cool river water, which quickly triggers larval release. The larvae were then transported in cool, aerated water to a location where juvenile salmon and trout were collected by electrofishing. The fish were placed in a large container with pearl mussels for approximately 20 minutes, allowing the pearl mussel larvae to attach to the gills, and the fish were then released back into the river. This technique is now being used in other rivers in Scotland as part of the *Pearls in Peril LIFE+* project.

**Other reintroductions**

It was also considered important to examine the success of two intra-catchment reintroductions of pearl mussels that took place in the Cairngorms in 2005. During this earlier project, a total of 950 adult mussels were moved to two tributaries in two separate, large river catchments. Monitoring within both tributaries in 2010 recorded between 6% and 10% of the original reintroduced mussels (Hastie et al., 2010). It was thought that the majority of the losses from the original reintroduction could be explained by individuals having been washed downstream. The 2010 monitoring did record signs of reproduction in both tributaries and therefore concluded that the reintroduced mussels were able to produce larvae up to five years after transfer. However, no larvae were recorded on the gills of any resident salmon or trout in either tributary. The reasons for the failure of these reintroduced mussels to infect the local fish population are unclear, despite investigations.

**Restoration**

An important action was to restore habitat where it was degraded, thus contributing to the aim of maintaining or increasing in size all currently viable pearl mussel populations.

Earlier work had identified a dam within a Special Area of Conservation in Lochaber that denied access for salmonids to the upper reaches of a watercourse that supports freshwater pearl mussels. The dam was thought to have been installed approximately 80 years ago, isolating the pearl mussels in the upper reaches from migratory fish populations. A partnership of SNH, the Scottish Environment Protection Agency (SEPA) and the Lochaber Fisheries Trust designed a suitable fish pass for the dam and it was installed during 2010 (Fig. 4). Subsequent monitoring has been unable to establish if the pass has been used by sea trout. However, it will be maintained into the future and should help ensure that this isolated and vulnerable pearl mussel population has a more robust fish host population to support its early life stages.
Other, much larger, catchments were identified as having been adversely affected by past river engineering. In these catchments, this activity seems to have limited the extent and quality of habitat for freshwater pearl mussels. Among other things, the presence of bank protection, bridges and waste-water treatment works has been found to be negatively correlated with the presence of freshwater pearl mussels in the River Dee (Cooksey et al., 2012). In partnership with SEPA, three catchment-scale restoration projects were commissioned to identify the locations where the removal or alteration of structures such as bank protection, weirs or croys would lead to the reinstatement of natural processes and the improvement of pearl mussel habitat. These projects examined the Rivers Dee, South Esk and Naver. This work required careful planning and, in each case, information about the presence of physical structures in and around the river was collected from maps, aerial photographs or field surveys. The relative impact of each structure on local river habitat conditions was then assessed by experienced fluvial geomorphologists. Once the different structures and their impacts on habitat were known, those structures whose restoration would provide the most significant benefits were identified. Such restoration should, in turn, provide improved and more resilient habitat conditions for the resident freshwater pearl mussel populations.

The three catchment restoration plans were produced in 2011 and 2012; however, their implementation clearly requires the full agreement of river and fishery owners. Consultation with river managers was part of the planning work in 2011 and 2012. Further discussions have continued since then and work to implement some of the physical restoration actions described in these plans is expected to begin during 2014. This will be done with the agreement of local river and fishery owners, as an integral part of the Pearls in Peril LIFE+ conservation project.

Besides the quality of the habitat within the river channel and on the river bed, the quality of the habitat on the river banks and surrounding land is also of great importance. The presence of native trees and vegetation alongside the river can benefit pearl mussels. Tree roots can help to bind the river banks and extend into the edge of the river bed, providing useful stable habitat for pearl mussels. Riverside trees also give shade to reduce temperature fluctuations, particularly during hot summers, and provide leaf litter and invertebrates that fall into the river and benefit the pearl mussel’s salmonid fish hosts (Fig. 5). Well-managed surrounding land also reduces the amount of silt and other pollutants that could otherwise enter the river and damage pearl mussels. Siltation is often the greatest threat to many pearl mussel populations (Skinner et al., 2003), so to encourage good practice, advice was given to land managers around five watercourses that support important pearl mussel populations. The aim was to encourage them to enter into appropriate agreements under the Scottish Rural Development Programme (SRDP). This was only partly successful because of insufficient incentives from SRDP, the complexities of the application process and the practical problems in making coordinated applications from different land managers along a single watercourse. However, further work to encourage greater uptake of appropriate SRDP measures is taking place in at least five further river catchments as part of the Pearls in Peril LIFE+ conservation project.

Further to this, SEPA began a programme to reduce rural diffuse pollution in March 2010. To do this SEPA appointed dedicated priority catchment coordinators to investigate the issues in each catchment and liaise with local land managers to bring about improvements. Some of the catchments were selected because of the problems faced by their pearl mussel populations. Since then, in one catchment as an example, approximately 400 km of riverbank has been walked to collect information on good and bad practice. Follow up visits have also been made to relevant land managers to provide advice, leading to an improvement in land management.
Wildlife crime

The freshwater pearl mussel is a UK wildlife crime priority because of the continued threat it faces from criminal damage. During the Species Action Framework, considerable evidence was found of damage from criminal activities (Cosgrove et al., 2012). In 2010 about 75% of protected sites for pearl mussel were found to have been damaged by suspected criminal activity. This damage was the result of pearl fishing and unauthorised river engineering works. In one case it was estimated that a single pearl fishing event killed 50% of the remaining freshwater pearl mussels, putting the future survival of the population in serious doubt. For reasons unknown, Scotland is unusual in being the only country in Europe where there is such a serious threat from pearl fishing, and evidence such as piles of dead shells on the river bank can still be seen (Fig. 6).

An important part of combating wildlife crime is raising awareness of the issue and the species it affects. The Species Action Framework funded the production of a leaflet telling people about the pearl mussel, why it is important, and what they can do to help (SNH, 2009). The leaflet was produced by a partnership of SNH, the National Wildlife Crime Unit and police forces in Scotland, and distributed by police forces across Scotland as part of ‘Operation Caesar’ during 2009. Further leaflets were also produced to highlight freshwater pearl mussels to water-sport enthusiasts and those planning river engineering activities. These actions and the publicity they have generated have increased the profile of freshwater pearl mussels and encouraged greater reporting and recording of crimes affecting the species. One outcome of this was the successful prosecution in 2013 of a developer and its contractors for causing pollution that killed many pearl mussels in Perthshire. This was the first successful prosecution for damaging pearl mussels in Scotland.

Host fish

As freshwater pearl mussels have an unusual life cycle and, for nearly all of their first year, live within a cyst which they harmlessly form on the gills of young native salmon or trout, the status of fish stocks in pearl mussel watercourses can be of critical importance. The status of salmon and trout stocks is relatively well known in many of the larger rivers, especially those that support important fisheries. However, many important pearl mussel populations are present in smaller rivers and burns,
typically in the north and west Highlands. Much less is known about the status of host fish stocks in those sites. Concerns have been raised about the possible effects of declining fish stocks on pearl mussels, particularly in the north and west Highlands (Hastie and Cosgrove, 2001).

To identify pearl mussel populations at greatest risk from low salmonid densities, SNH and the Rivers and Fisheries Trusts of Scotland (RAFTS) worked in partnership to undertake surveys of juvenile fish using standard electrofishing techniques in locations that support pearl mussel populations. The results identified a series of rivers where fish densities appear to be adequate to support reproduction (Sinclair, 2011). However the survey also identified pearl mussel populations that appear to be at greatest risk from low salmonid densities. This was the first time such a comprehensive study of fish stocks to inform pearl mussel conservation had been undertaken in Scotland and it filled an important knowledge gap that can help direct conservation action. Conservation action is now under way or being planned in the identified higher-risk rivers and burns to improve the status of the fish stocks. This, in turn, will improve the conservation status of the resident pearl mussels. Actions include improving riparian habitat to benefit both fish and pearl mussels, removing further obstacles to fish migration and restoring straightened river channels to their original shape which will support better habitat.

However, as the host fish surveys were nearing completion, an important finding came to light. It had previously been thought that pearl mussels in Scotland tended to use Atlantic salmon as their principal host but were able to use trout when salmon were unavailable (Hastie and Young, 2003). However, evidence from Norway showed that local freshwater pearl mussel populations can have more specific host fish requirements than previously thought (Larsen and Karlsson, 2012). This study found that in one river pearl mussels may only use trout as their host, despite salmon being present, and conversely in another river may only use salmon, despite trout being present. The reason for this host specificity is not clear but there are suggestions that it may be genetic (Larsen and Karlsson, 2012). Since the end of the SAF project, continuing work in Scotland suggests that the same host specificity may occur here too (Elizabeth Clements, pers. comm.).

Lessons Learnt, Further Work and Future Recommendations

- **Reintroduction** – the work demonstrated that moving adult mussels and infecting wild fish with pearl mussel larvae can both be used to reintroduce freshwater pearl mussels in Scotland. It also showed that, after considerable planning, the reintroduction itself can be straightforward and cost relatively little.

- **Reintroduction** – during the work, we tried to test the suitability of river-bed habitat for freshwater pearl mussels using redox potential but this was unsuccessful. Further work is needed on this or on other techniques.

- **Reintroduction** – land managers, owners and fishery interests must be consulted at a very early stage when planning a reintroduction, and this should continue during and after the work.

- **Restoration** – SAF provided the opportunity and the funds to undertake catchment-scale restoration plans and to identify the most important opportunities within large and complex catchments. These plans and other actions within SAF have helped to foster successful partnerships resulting in the Pearls in Peril LIFE+ project that will last until 2016. This new project, with a budget of £3.5 million, has been needed to implement the actions within those plans.

- **Wildlife crime** – raising the awareness of wildlife crime among important river users, including fishermen, canoeists, rafters and walkers has led to greater reporting of suspicious activity and suspected crimes to the police.

- **Host fish** – the SAF project provided the first information on host fish populations in many of the rivers that support our most important pearl mussel populations. Further work is needed to confirm whether particular pearl mussel populations are using trout and/or salmon as their host so that conservation management can be effective. This should be done by monitoring the number of pearl mussel larvae on the gills of the young fish.
New and ongoing work since SAF ended

The most significant new work since SAF ended is the Pearls in Peril LIFE+ project, which aims to improve the conservation of the pearl mussel in 21 Special Areas of Conservation. This project builds on the partnerships established by the SAF freshwater pearl mussel project. It is also implementing work that was developed under the SAF project, particularly the catchment-scale restoration plans. But the LIFE+ project is also undertaking new work such as planting riparian woodlands, reducing diffuse pollution and reinvigorating two extremely small pearl mussel populations. The Pearls in Peril LIFE+ project is also involving partners beyond those who worked on the SAF project, particularly Forest Enterprise Scotland (FES). FES is now undertaking considerable management that is specific to pearl mussels, including blocking drains to reduce sediment input, restoring native woodlands on river banks and providing training to forest workers across northern Scotland.

The freshwater pearl mussel also remains a UK wildlife crime priority and so work to raise awareness of the threat posed by criminal activity is continuing. This includes developing future publicity plans and launching ‘Riverwatch’ schemes to encourage better reporting of criminal activity on vulnerable rivers.

Action by SEPA and others to reduce diffuse pollution in catchments that support important pearl mussel populations will continue and, from 2015, extend to a number of other river systems.

Key Management Messages

• Before taking action for a population it is important to identify the threats. These may be in the river, but could also be elsewhere in the catchment; they may be affecting host fish, or may be from persecution.

• A partnership approach has been most effective at implementing actions that will benefit pearl mussels. Creating good conditions for pearl mussels also creates good conditions for many other species and habitats in and around the river.

• Many pearl mussel populations are threatened by siltation, from various sources. Addressing this successfully usually needs careful work with land managers over a very wide area in a number of key catchments.

• Raising awareness of pearl mussels improves the reporting of suspicious activity and reduces the threat posed by criminal activity.
Further Information


References


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The SAF Partners

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- University of Aberdeen
- Environment Agency
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- Marine Scotland
- Scottish Environment Protection Agency
- Lochaber Fisheries Trust
- National Wildlife Crime Unit
- The James Hutton Institute
- Natural England

The Species Action Framework Handbook

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Great Yellow Bumblebee

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Summary

- The great yellow bumblebee is the UK’s rarest bumblebee. It has disappeared from over 90% of its original range in the last 50 years and is now restricted to northern and western Scotland, especially on machair and other flower-rich habitats.
- A comprehensive monitoring handbook for volunteers was developed and a network of local volunteer recorders trained to carry out great yellow bumblebee surveys and monitoring transects (bee walks).
- Demonstration plots have been set up along the north coast of Scotland with local groups, promoting appropriate grassland management to benefit the great yellow bumblebee.
- Information packs on the great yellow bumblebee, produced by the Bumblebee Conservation Trust (BCT) in English and Gaelic, have been widely distributed. They include posters and leaflets for crofters and educational material for schools.
- A database of all verified records of the great yellow bumblebee on the National Biodiversity Network (NBN) Gateway has been compiled to provide a reliable and up-to-date resource on the current distribution of the species.
- Under the Scottish Rural Development Programme (SRDP) a substantial number of Rural Development Contracts were awarded over the period 2008-14 in the Western Isles, Tiree and Coll for habitat management options likely to benefit the great yellow bumblebee. These options remain available under SRDP 2014–2020.
- Habitat management and monitoring work for the great yellow bumblebee is continuing with support from the BCT Conservation Officer for Scotland.

Introduction

Species background

In the UK, eight bumblebee species have undergone significant decline in range, of which the great yellow bumblebee (Bombus distinguendus) (Fig. 1) has suffered the largest reduction (Goulson, 2003). The great yellow bumblebee is widespread in northern and central Europe and in Asia, although it is declining in many parts of its range. Once distributed throughout Great Britain, its range has contracted by 95% in the last 50 years (Benton, 2006). Its main populations are now confined to parts of north and west Scotland, mainly in the Western Isles, Orkney, Coll and Tiree, and Caithness, with small scattered centres in coastal Sutherland. This decline, particularly evident since the 1960s, is thought to be linked to increasing intensity of farming, resulting in a lack of appropriate flowers to provide pollen and nectar (Macdonald and Dawson, 2010).

Fig 1. Great yellow bumblebee.
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Bumblebees occupy a wide range of habitats, but are particularly abundant in flower-rich, semi-natural grasslands and heathland, almost exclusively below 100 m altitude (Goulson, 2003; Williams and Osborne, 2009). The great yellow bumblebee is associated with open grasslands and meadows that provide abundant and continuous forage resources throughout the flight period. These habitats support high densities of plant species with flowers that have a long corolla, notably those from the families Leguminaceae, Lamiaceae and Fabaceae.

In Scotland, the great yellow bumblebee is strongly associated with flower-rich machair habitats on the north-west coast (Benton, 2006), but it is also found in association with more conventional agricultural systems in Orkney and Caithness. In the
Western Isles, it occurs in machair patches, where it feeds on bird’s-foot trefoil (*Lotus corniculatus*), red clover (*Trifolium pratense*) and knapweeds (*Centaurea* spp.). In Sutherland and Caithness, it occurs on dunes where species of the clover family, knapweeds and marsh thistle (*Cirsium palustre*) are the main forage plants. In Caithness and Orkney, it uses a range of unimproved habitats such as coastal heath and weedy edges of cereal fields where marsh thistle and woundworts (*Stachys* spp.) are important forage plants (Hughes, 1998).

No single plant species provides resources throughout the season, so the great yellow bumblebee requires a succession of forage species in order to complete its cycle and produce males and new queens (Charman, 2007). Small, scattered patches of flowers are suitable, provided that these patches supply food continuously throughout the season. Management should aim to provide forage continuously from May or June to the end of September.

The breeding cycle of the great yellow bumblebee is particularly short, an adaptation to the relatively brief northern summer (Macdonald, 2003; Benton, 2006). It is active between May and September, and it nests relatively late in the season. Nests are constructed underground, usually among tussocks and in old burrows of small mammals such as wood mice. Adults are relatively large, but there are relatively few (20-50) workers per nest (Macdonald, 2003).

### History of decline, contributory factors and current threats

Over the past century, the UK has lost vast areas of semi-natural habitats as a result of agricultural intensification (Fuller, 1987; Robinson and Sutherland, 2002). These profound changes in the landscape have reduced the availability of bumblebees’ three main requirements: nesting sites, a supply of pollen and nectar throughout the season, and suitable places to hibernate (Sladen, 1912; Free and Butler, 1959). However for many researchers, the reduction of flower resources is the main driver of the decline of the great yellow bumblebee as well as other species (Fussel and Corbet, 1992; Goulson *et al*., 2005; Carvell *et al*., 2006; Goulson *et al*., 2008; Williams and Osborne, 2009).

Threats to the great yellow bumblebee’s habitats arise from heavy summer grazing, reduction in rotation period, addition of fertilisers, adoption of silage and monoculture, loss of herb-rich grasslands and alteration of grazing practices, such as the abandonment of traditional Hebridean cattle-rearing regimes and rotational machair cropping.

Actions to protect the great yellow bumblebee are also likely to benefit a range of other insect species, notably the northern colletes (*Colletes floralis*), a mining bee included on the UK Biodiversity Action Plan (UKBAP) priority species list.

### Aims

#### Objectives for 2007-2012

The objectives of the Species Action Framework (SAF) implementation plan for the great yellow bumblebee were to:

- Set up and train a network of local volunteer recorders, and establish a programme of annual survey and monitoring of the great yellow bumblebee to provide baseline data and measures of abundance.
- Create demonstration plots of great yellow bumblebee habitat involving local groups along the north coast of Scotland.
- Distribute and promote advisory and education materials about the great yellow bumblebee to primary schools and to relevant land managers including crofters.
- Investigate opportunities for using the SRDP to benefit great yellow bumblebee populations.

### Management Action

A steering group was set up to take forward actions for the great yellow bumblebee. This included representatives of Hymettus (formerly the Aculeate Conservation Group), BCT, Scottish Natural Heritage (SNH), Royal Society for the Protection of Birds (RSPB), Highland Council Ranger Service, and local biodiversity groups for the Western Isles, Orkney, Caithness, Sutherland, and Argyll and Bute.
Summary of the main actions carried out

• **Training teams of local volunteer recorders** – around 30 individuals were trained to survey and monitor the great yellow bumblebee. A comprehensive handbook *Bee Walks* was prepared by the Bumblebee Conservation Trust (BCT) to assist training and to advise recorders on field techniques (Dawson and Mabon, 2010).

• **Establishment and maintenance of demonstration plots** of great yellow bumblebee habitat, involving local groups along the north coast (John O’Groats, Dunnet, Melvich, Tongue and Durness). Further details are given below.

• **Distribution of information packs** about the great yellow bumblebee (produced by BCT) - 1,297 English and 150 Gaelic leaflets, and 153 English and 10 Gaelic posters were distributed. Education packs were delivered to around 70 schools.

• **Uptake of SRDP** to benefit great yellow bumblebee – see text below.

• **Compilation and update of a single database** of all verified records of the great yellow bumblebee on the National Biodiversity Network (NBN) Gateway – this has provided a reliable and up-to-date resource on the current distribution of the species. This dataset can be used to advise management projects (for example, local initiatives, agricultural support mechanisms, planning decisions).

**Demonstration plots**

In Caithness, a 750 m² site at Murkle Beach was planted with knapweeds, kidney vetch (*Anthyllis vulneraria*), red clover and field scabious (*Knautia arvensis*). Great yellow bumblebee was recorded on this plot in 2010 during four visits by one volunteer.

In Sutherland, a 2,500 m² site not grazed during summer at Balaclava Park, Melness, was enhanced with a wildflower/grass seed mix including yellow rattle (*Rhinanthus minor*), bird’s-foot trefoil, tufted vetch (*Vicia cracca*) and black knapweed (*Centaurea nigra*) which were sown into the existing grass sward. Limited germination occurred, with yellow rattle evident in 2010. No great yellow bumblebees have been seen on this plot, but the UKBAP Priority species moss carder-bee (*Bombus muscorum*) was recorded.

Improved management, supported by the residents, of 2,000 m² of grassland behind Balnakeil Craft Village near Durness in Sutherland has been instigated and is expected to improve plant species richness and diversity. A mechanical cutter, purchased with SAF project funding, is being used by BCT for site management. This equipment will have wider benefit elsewhere in Sutherland, where demonstration plots or ‘stepping stones’ for bumblebee dispersion are all expected to be grassland sites. Great yellow bumblebees and moss carder-bees have been seen on the site. Control of creeping thistle (*Cirsium arvense*) will be required.

An interpretation board (Fig. 2) has been placed at Dounreay (Fig. 3), and another is to be placed at Balnakeil.

![Fig 2. Design for the interpretation boards.](image)

![Fig 3. The interpretation board in place at Dounreay.](image)
SRDP support for management

The ‘Rural Development Contracts – Rural Priorities’ scheme (RPS) offered under SRDP from 2007 to 2014 allowed farmers and crofters to take up management options conducive to maintaining great yellow bumblebee habitat in known population strongholds. The SAF project started after the RPS management options had been devised and agreed with the European Union, and so the scheme did not offer an option specifically targeted at great yellow bumblebee. However, SAF was specifically identified as a Rural Priority under SRDP, and there was a wide range of existing options that supported appropriate management for this species, in particular:

1. Wild Bird Seed Mix/Unharvested Crop
2. Grazed Grassland for Corncrakes
3. Creation and Management of Cover for Corncrakes
4. Management of Cover for Corncrakes
5. Open Grazed or Wet Grassland for Wildlife
6. Management of Species Rich Grassland
7. Creation and Management of Species Rich Grassland
8. Management of Habitat Mosaics
9. Cropped Machair

And to a lesser extent:
10. Grazing Management of Cattle
11. Mown Grassland for Wildlife
12. Mown Grassland for Corn Buntings
13. Mown Grassland for Corncrake or Choughs

RPS was administered within Regional Proposal Assessment Committee (RPAC) areas. Stronghold populations for the great yellow bumblebee generally fell into the Outer Hebrides and Argyll RPAC areas. The sparser populations on the north and west Highland coast were within the Highland RPAC area. The scheme was competitive but applicants seeking to manage land within protected areas, or where land was to be managed for specific ‘biodiversity’ and SAF species, were scored more highly, particularly where the expected outcomes met more than one of these priorities.

In general, most applications were aimed at managing habitats or species specified in the available options (such as machair grassland, machair cropping, corncrake, wader habitat and wetland) but applicants, and their agents, often cited great yellow bumblebee as an additional target, as the habitat was known to support this species in their location, and this bolstered their application. Unless there were cross-cutting eligibility issues the RPACs generally supported these cases to the extent that a minimum of 200 Rural Development Contracts were awarded across the Outer Hebrides and Inner Hebridean islands of Tiree and Coll over the period 2008–14, for habitat management likely to suit the great yellow bumblebee. The later cases will continue to deliver management beyond this and up to the end of their five-year contract period.

All the options listed above are still available in the latest version of SRDP (2014–2020) and it is anticipated that many crofters and farmers will apply to continue management for another five years, beyond their current contracts. It is also hoped that others within the bumblebee’s range will enter appropriate schemes to manage grassland in a way that benefits this species.
The general feeling from partners was that the SAF project was a great success even though not all objectives were met in full and some of the original plans were altered in light of circumstances and experience. The greatest obstacle arose from the short duration of funding: invertebrate abundance and activity are subject to fluctuations caused by weather conditions and normal annual variations, thus successful and reliable monitoring is by its nature a long-term exercise. Several years of data collection are required to establish a baseline state against which to measure annual changes, and many more years beyond that to identify local or national trends.

Take-up of RPS options likely to benefit great yellow bumblebee under SRDP in Coll, Tiree and the Western Isles was encouraging, helped by the inclusion of SAF species as rural priorities. Hopefully this can continue under SRDP 2014–2020.

Some of the monitoring and habitat management work is continuing under the auspices of BCT, which has secured funding from SNH and the Heritage Lottery Fund (HLF) for a dedicated Conservation Officer for Scotland. The post is principally targeted at conserving the great yellow bumblebee, working with volunteers trained through the SAF project. Monitoring continues with more volunteers being sought in the key great yellow bumblebee areas, and this work is further supported by the BCT Surveys Officer (responsible for analysis of monitoring data) funded by Esmee Fairbairn Foundation.

The SAF work has laid a foundation of interest and commitment among the communities in great yellow bumblebee areas and has provided a sound starting point for continuation of the work. Through raising awareness of the bumblebee, its national importance, and the conservation measures needed for its survival, we hope that appropriate management practices will be expanded to enhance the population on the mainland. We will have at least three foci for the bee in Balnakeil, Farr (a pre-SAF project) and Dounreay where the public will have the opportunity to become aware of the importance of the area for great yellow bumblebee and other species through the on-site interpretation. Other projects aiming to enhance

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**Key Management Messages**

- Changes in agricultural practices, especially the loss of permanent, flower-rich meadows, are the main threats to the great yellow bumblebee.

- Management should aim to promote good stands of red clover and common knapweed, which are important forage plants, as well as plants with long-corolla flower types, especially those belonging to the families Leguminaceae, Lamiaceae and Fabaceae.

- Traditional Hebridean cattle rearing and rotational machair cropping provide suitable habitat and should be encouraged. There should be no sheep grazing, with light grazing by cattle between April and mid-September, preferably in the form of rotational strips.

- Occasional arable crops (such as potatoes and barley) are beneficial because they promote a flush of wildflowers in the following year.

- Management areas must be large because the great yellow bumblebee nests at very low densities (one or two nests per square km).

- Actions to protect the great yellow bumblebee are likely to also benefit the northern colletes mining bee, a UKBAP Priority species.
great yellow bumblebee habitats will continue because of the interest and enthusiasm generated by the SAF work, and the involvement of RSPB in managing their sites within the bee’s distribution range.

Further Information

- [www.bumblebee.org](http://www.bumblebee.org) – page dedicated to the ecology and biology of bumblebees.
- [www.nhm.ac.uk/research-curation/research/projects/bombus/bumblebeeid.html](http://www.nhm.ac.uk/research-curation/research/projects/bombus/bumblebeeid.html) – Natural History Museum bumblebee identification guides.

References


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The SAF Partners

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- The Bumblebee Conservation Trust
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Marsh Fritillary Butterfly

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Summary

• The marsh fritillary (Euphydryas aurinia) has a restricted range in Scotland centred on Argyll and the neighbouring islands, and these colonies are some of the most important in Europe. Furthermore, the butterfly is closely linked to traditional agricultural management, requiring light grazing to maintain its habitat in suitable condition. The main aim under the Species Action Framework (SAF) marsh fritillary project, therefore, was to deliver appropriate management advice to benefit the butterfly at a landscape scale.

• A steering group was formed comprising Scottish Natural Heritage (SNH), Forestry Commission Scotland (FCS) and Butterfly Conservation Scotland (BCS), who jointly funded a Project Officer to do this work. The project also included action on the two other SAF-listed Lepidoptera, pearl-bordered fritillary (Boloria euphrosyne) and slender Scotch burnet moth (Zygaena loti), as well as the chequered skipper butterfly (Carterocephalus palaemon).

• The project objectives were achieved by working in close partnership with Scottish Agricultural College (SAC, now called the Scotland's Rural College, SRUC) and Agrimony (an Argyll-based agricultural advisory business) to provide site-specific management advice for marsh fritillary to their clients, to help them gain entry into the Scotland Rural Development Programme (SRDP) Rural Priorities (RP) scheme. Through this partnership the Project Officer took on the role of specialist adviser.

• Management advice was given across 20 meta-populations, with involvement at a minimum of 202 sites; 114 of these were successfully entered into Rural Priorities, and 76 other sites were visited and management discussed with the owners. However, not all sites were eligible or suitable for entry into RP, highlighting issues with the scheme.

• The success of this project is primarily due to the co-operation and goodwill of the site landowners/managers and their agents and the willingness to work together.

Introduction

Species background

The marsh fritillary butterfly has suffered declines throughout Europe. The British Isles, particularly Scotland, is considered one of its few strongholds, being home to some of the most important populations in Europe. Severe declines, particularly in England and Wales, led to the butterfly being listed as a UK BAP Priority species as well as being on the Scottish Biodiversity List. It is also included on Annex II of the EC ‘Habitats Directive’ and it is protected under the Wildlife and Countryside Act 1981 (as amended).

The butterfly has become extinct over a large part of its former range in England, Wales and Northern Ireland, whilst even in Scotland it has declined in distribution by around 12% since the mid-1980s, compared to an overall UK distribution decline of 46% between 1970-1982 and 1995-2004 (Fox et al., 2006). Despite conservation efforts, the butterfly still declined in distribution in the UK by 9% between 1995-99 and 2005-09 (Fox et al., 2011). Declines in abundance at monitored sites have been even steeper at 73% between 1983 and 2004 (Fox et al., 2006). There have also been similar dramatic declines recorded in Europe.

Our general knowledge of the butterfly’s distribution in Scotland is good although its current status is unclear. This is because the last full Scottish survey was undertaken in 2002 (Ravenscroft et al., 2003) and too few sites are monitored each year for annual population fluctuations to be adequately determined, although more recent surveys have been conducted on Islay (Ravenscroft et al., 2007). Previous survey work identified Scottish marsh fritillary strongholds and led to the species being included as a qualifying feature in five Special Areas of Conservation (SACs); one on Islay (Ravenscroft, 1996) and four on mainland Argyll.

In Scotland marsh fritillary has a limited distribution, being restricted to the Argyll islands and the neighbouring strip of Argyll mainland, although new colonies have recently been found both to the north and south of its former known Scottish distribution: on and adjacent to Bute, and in south-west Highland. This possibly indicates that the butterfly is colonising new areas although it is more likely to be due to increased recording effort in these remote locations.
The declining fortunes of this species are primarily due to habitat loss and inappropriate management leading to the fragmentation of suitable habitat, resulting in the isolation of existing colonies (Hobson et al., 2001). This is particularly damaging to marsh fritillary as populations are more robust if they form part of a network of linked habitat patches forming sustainable metapopulations, where local losses or extinctions can be balanced by re-colonisations from neighbouring colonies (Hobson et al., 2002; Bulman et al., 2007). This highlights the importance of working at a landscape scale and is why BCS identified 10 Landscape Target Areas across Scotland. These highlight the most important landscapes for key Lepidoptera in Scotland. Four of these landscapes have been identified primarily for marsh fritillary and thus help to prioritise where work on marsh fritillary in Scotland should be focused. Conversely it is unwise and not sustainable to conserve marsh fritillary solely on protected areas, or on small and isolated sites. Successful conservation action for marsh fritillary therefore requires positive engagement with landowners and land managers at a landscape scale (Bourn et al., 2013).

The butterfly’s ecology and management requirements are fairly well understood, particularly in England and Wales, which has enabled appropriate management prescriptions to be developed to benefit the butterfly and other wildlife that shares its habitat. This combination of factors, (i) a threatened species whose ecology is well known, with previously proven positive management techniques, and (ii) a species that continues to decline and for which Scotland now represents a stronghold, made marsh fritillary an ideal candidate for prioritising through SAF.

**General ecology**

In Scotland the marsh fritillary occurs in a wide range of habitats including damp/wet and species-rich grassland, rush pasture, damp moorland and coastal heath. It also occurs in a variety of settings away from the more traditional unimproved grasslands, including road and trackside verges, woodland and forestry glades/clearings and the margins of hay/silage fields, and from upland heaths to coastal grassy swards.

It is one of four fritillary butterflies in Scotland. The three other species differ in appearance from marsh fritillary by having a uniform orange/brown background colour, with an intricate pattern of darker black/brown markings, whereas the marsh fritillary is more colourful, with a checkerboard pattern of orange, cream, brown and black.

The adult butterflies are on the wing from mid-May to early July. The female butterfly lays her eggs in batches of 20 to 80 on the underside of the leaves of the caterpillar’s sole Scottish foodplant, devil’s-bit scabious (*Succisa pratensis*).
On hatching, usually in July, the caterpillars stay together, living communally within a protective silken web they spin themselves. They subsequently overwinter in a more toughened web within a tussock and re-emerge in early spring to continue their development, still feeding on the leaves of devil’s-bit scabious.

The butterfly is most easily monitored by systematic counts of its distinctive communal larval webs in the autumn, usually during August and September. This also coincides with the scabious being in flower which helps identification of areas to search. The method also has the advantage that it is not weather-dependent and identifies breeding sites. The adults can also be monitored using standard butterfly monitoring techniques e.g. by transects or timed counts. However, the butterfly has highly dynamic population levels from year to year, being very abundant in some years, yet scarce in others. This is due to a combination of factors including weather and the impact of a parasitic wasp whose grubs feed within and kill the caterpillars. Consequently it can be very difficult to identify population changes that are due solely to adjustments in management in the very short-term.

**Habitat management**

Maintenance of suitable marsh fritillary habitat is best achieved through light grazing, ideally by cattle or ponies/horses.

However, due to the varied and non-uniform nature of marsh fritillary sites in Scotland, a standard grazing prescription that fits all sites is not applicable. This differs from other priority farmland species for which standard management prescriptions can be applied successfully through agri-environment schemes, such as corncrake (Crex crex), chough (Pyrrhocorax pyrrhocorax), lapwing (Vanellus vanellus) and other breeding waders. Management advice for marsh fritillary in Scotland has to be site-specific, yet delivered on a landscape scale, with the aim of creating/enhancing sufficient, suitably connected habitat.

This is best achieved by:

- Creating and/or maintaining patches of abundant devil’s-bit scabious, ideally in an uneven patchwork of short and tall vegetation 5-25 cm in height (Barnett et al., 1995).
- Ensuring a good supply of nectar sources for the adult butterflies, including orchids and ragged robin (Lychnis flos-cuculi), preferably in sunny and sheltered locations.
- At most sites, light grazing by cattle and/or ponies/horses, at between 0.2 and 0.3 livestock units per ha per year, will maintain/enhance suitable habitat. This can be achieved through all-year grazing, although grazing should not exceed 0.2 livestock units per ha during June to August. Suitable conditions can also be achieved through seasonal grazing, usually with a summer and/or early autumn grazing break to improve floristic diversity by allowing wildflowers to set seed.
- Traditional breeds of cattle are better as they are less selective grazers and feed on rougher vegetation. They are also hardier and can therefore graze throughout the year. Sheep are often unsuitable for maintaining sites in good condition (Warren, 1994), particularly if not used in combination with cattle/ponies, or if grazed at high densities in late summer and early autumn, as they can selectively feed on devil’s-bit scabious. Over time this can reduce or even eliminate devil’s-bit scabious from the sward.
- Some scrub and trees can be tolerated within marsh fritillary habitat particularly around the perimeter as this provides shelter. However, the formation of new scrub within the centre of suitable habitat is far less beneficial as it can both dry and shade it out. It can also lead to further scrub establishment due to the closer proximity...
of the seed source. Once scrub over 1 m high occupies more than 10–15% of suitable habitat it should be controlled.

- In the absence of sufficient grazing, mowing can prevent sites becoming too rank, excessively tussocky or overrun with scrub. It can also be used to restore sites that have deteriorated, where tussock-forming rushes or purple moorgrass (*Molinia caerulea*) have become too dominant, particularly as a precursor to reinstating grazing. In most cases rotational cutting every fourth or fifth year should maintain areas of suitable habitat.
- Artificial fertilizer, manure, slurry or pesticides should not be applied to sites.

It is important to have a flexible approach to the management of marsh fritillary habitat and that variation between years of plant growth, rainfall, seasonality, as well as availability of stock are taken into account. Allowing for such fluctuations is best managed by the person with the best knowledge of the site, i.e. the site manager or grazer, providing they have a good understanding of the butterfly’s requirements and management objectives. It is also good practice for the management to be reviewed at the end of each year so that suitable adjustments, to grazing pressure for example, can be implemented for the next year. This will also help to inform future management decisions.

**Aims**

**Aims and objectives for 2007-2012**

The overall aim of the SAF marsh fritillary project was to influence land management to enhance the habitat for the butterfly, rather than undertaking research, survey and/or monitoring. The key objectives of the project were to:

- Maintain the butterfly’s current range in terms of 10-km squares.
- Identify all networks, and within these, identify all key ‘source’ sites.
- Ensure that all ‘source’ sites in each network are in favourable condition.
- Increase viability of all networks by increasing the extent of suitable habitat and/or by enhancing links between sub-populations.

**Management Action**

**Summary of the main actions carried out**

The objectives were achieved by:

- **Specialist adviser** – a Project Officer was employed to provide specialist advice.
- **Bringing land into suitable management under SRDP Rural Priorities** – the Project Officer assisted landowners/managers, in partnership with their agents, to gain entry to Rural Priorities (RP) and ensure appropriate management, mainly through implementing site-specific grazing regimes.
- **Specific management activities** – in addition to implementing suitable grazing regimes other specific management carried out included scrub removal, fencing, bracken control and provision of water troughs.
- **Awareness raising** – the BCS colour leaflet *Learn About the Marsh Fritillary* was updated and reprinted and the project promoted via various talks and press articles.

**Action before the Species Action Framework**

Prior to SAF BCS had undertaken various activities on marsh fritillary including a series of butterfly workshops in parts of the butterfly’s range, for example near Lochgilphead, Oban and on Islay. These were primarily aimed at volunteers to encourage increased recording and monitoring. In addition a number of demonstration days were held in partnership with other organisations, agencies, landowners and land managers to highlight the butterfly’s habitat and management requirements, and the significance of the colonies in Argyll. These proved invaluable by raising the profile of marsh fritillary and making good initial contacts with organisations, key landowners and agency staff who subsequently all became key players in the marsh fritillary SAF project.

A colour leaflet *Learn About the Marsh Fritillary* had also been produced aimed at both recorders and land managers. It provides useful information on the butterfly: its life-cycle, identification, ecology and habitat management requirements.
Steering Group and Project Officer

A steering group was formed in 2008 comprising SNH, FCS and BCS. This group jointly funded a Project Officer, employed by BCS, to encourage appropriate action on the ground for marsh fritillary. The Project Officer’s role included action for the two other SAF-listed Lepidoptera, pearl-bordered fritillary and slender scotch burnet moth, and for chequered skipper, which is listed as a priority species in the Scottish Forestry Strategy. NTS also joined the steering group because of the important burnet moth colonies they manage on their property at the Burg. The group met once or twice a year to review the work undertaken and to help steer future work on all four species.

Initial plans

The original intention of the project was to target management advice for marsh fritillary at sites within the four Landscape Target Areas identified by BCS for the butterfly, with any management work being paid for directly out of the SAF project budget.

Initially this work was focussed on the Appin area of north Argyll, as this is a key area for the butterfly with a number of important sites and is readily accessible. However, this was not as straightforward as initially expected and several difficulties presented themselves:

- It was very difficult, primarily because of the Data Protection Act, to find out who owned or managed the sites where the butterfly had been recorded.
- If and when contact was established, usually by local enquiries close to where the butterflies had been sighted, landowners were mostly unaware that marsh fritillary was on their ground, or of BCS, or the Project Officer. This was usually resolved by informal discussion, which provided a good opportunity to explain the requirements of the butterfly with reference to two relevant BCS leaflets: *Learn about the Marsh Fritillary*, as well as the more general *Butterflies of Argyll an Identification Guide*.
- Despite the interest in the butterfly that this may have instilled, it often then became apparent that the land where the species had been recorded was currently being managed under a pre-existing agri-environment scheme, usually the Rural Stewardship Scheme (RSS). This meant that even if the existing grazing regime was detrimental to marsh fritillary, which was often the case, it was not possible to adjust the management until the end of the scheme, which could be anything up to five years away.

This all proved to be very frustrating.

Success through partnership

The timely launch of the Scottish Government’s SRDP Rural Priorities (RP) scheme in 2008 provided a useful delivery mechanism for this work. It soon became apparent that there was a niche for the Project Officer to act as a specialist adviser to assist landowners/managers, through their agents, to gain entry into the scheme. This was important as RP is a competitive scheme in which applicants enter their land for five years but need to ensure that their proposals are produced to a high standard, scoring as many points as possible, and thus improve their chances of a successful submission. The partnership between the Project Officer and the land owners/managers’ agents from Scottish Agricultural College (SAC) and Agrimony was particularly crucial as the agents knew when each of their clients was coming out of RSS and therefore interested in entering RP. The initial success of the first few applications gaining entry into the new RP scheme quickly bred further interest, and both agents and landowners/managers were soon proactively contacting the Project Officer to undertake site assessments for marsh fritillary to look for the presence of suitable or potential habitat.

This partnership proved invaluable by providing a crucial link between the landowner/manager, their agent, the case officer assessing the application and the species on the ground. It also guaranteed that only sites with suitable or potential habitat were entered into the scheme, whilst the close liaison ensured that the prescribed management, mostly extensive light grazing, was deliverable. The success was based on trust and the partners’ combined knowledge of the butterfly’s distribution and requirements, along with the agents’ local knowledge of sites and landowners, and the willingness to work together. The partnership was also actively encouraged by the Argyll RPAC, which assesses the resulting RP applications. Most Argyll farmers soon became aware that having marsh fritillary on their ground was beneficial to gaining entry into RP.

For each application the Project Officer provided a site-specific grazing plan along with supporting documentation outlining the importance of the site for the butterfly. The involvement of BCS also
made it easier for the case officers, who tend to lack specialised knowledge of the requirements of butterflies and moths, to assess the application.

The partnership worked very well and was aided by the butterfly having a restricted distribution that, on the whole, matched the boundaries of the Argyll RPAC, ensuring contact with just one RPAC committee and a limited number of agents, most of whom were from just two companies: SAC and Agrimony. Many of the agents and case officers had previously attended demonstration days which had highlighted the local significance of marsh fritillary. Also there was already a good working relationship between the RPAC, case officers and agents in Argyll that was enhanced and supported by regular meetings, usually held soon after each RPAC meeting. These meetings provided a good forum for agency case officers and local agents to openly discuss issues concerning the scheme.

**Results: SRDP applications**

Table 1 summarises the number of sites where specific advice on marsh fritillary was given, across 20 meta-populations. This shows that there was involvement with at least 202 sites, with 106 being successfully entered into SRDP, while a further eight are pending. In addition a further 76

<table>
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<th>Area</th>
<th>Approved SRDP</th>
<th>Pending SRDP</th>
<th>Visited</th>
<th>Other</th>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
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<td>-</td>
<td>5</td>
<td>1</td>
<td>12</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>106</strong></td>
<td><strong>8</strong></td>
<td><strong>76</strong></td>
<td><strong>12</strong></td>
<td><strong>202</strong></td>
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</table>
sites were visited and management discussed with
the owners. These sites were not entered into SRDP
for a number of reasons including:

• Little or no suitable/potential habitat for the
butterfly was found during the site visit, or the
site was ineligible for SRDP funding.

• There was little prospect of gaining entry into
SRDP, for example, because the application
was unlikely to score sufficient points, or the
area of ground was too small to make an appli-
cation financially viable.

• An application was unsuccessful, withdrawn, or
the landowner/manager was unable or unwill-
ing to implement the recommended manage-
ment to benefit marsh fritillary.

In a further 12 cases, more generic advice was
given, without visiting the site.

All sites in Table 1 are plotted alongside the
Scottish distribution of marsh fritillary (1980-2010)
in Fig. 4. It should be noted that the site location
symbol showing where advice has been given
(yellow triangle), is most often plotted on the
location of the relevant farmhouse, rather than
showing the individual fields or area being specifi-
cally managed for marsh fritillary or ground that
was assessed. At small sites, or where only small
areas of land were entered into the scheme, then
the site symbol often coincides very well with the
species record symbol (orange dots). However, at
large sites it mostly under-estimates the amount of
land being managed and in these cases many of
the adjacent species records will actually be under
sympathetic management. This makes interpreta-
tion of the mapped information difficult; however
it proved impossible to retrieve any spatial infor-
mation on the location, or area of land, being
managed for marsh fritillary under RP from the
SRDP system. In addition the orange dots do not
provide a measure of the numbers of marsh fritil-
ary recorded as each dot simply represents ‘a
record’, be that a single individual, tens or several
hundreds.

Both Table 1 and Fig. 4 show that advice has been
given across almost the entire Scottish range of
marsh fritillary as well as at sites on the edge of the
butterfly’s current distribution. This is particularly
important should the distribution of marsh fritill-
ary change because of climate change, or if popula-
tions at currently occupied sites on the edge of the
range increase as a consequence of improvements
in habitat quality through implementing the recom-
mended management advice.

Monitoring the effect of
management

In 2012 SNH funded a research study to monitor
marsh fritillary and current habitat condition at a
sample of sites being specifically managed under
RP for the butterfly. Base-line data were gathered
from 75 sites across 20 different meta-populations
using BC’s structured walk habitat assessment meth-
odology (Bulman et al., 2010). The initial results
indicate that marsh fritillary is currently in a trough
in its cycle at most sites, as very few larval webs
were located. Being a base-line survey the results
will be of particular interest once comparable data
becomes available through a repeat survey. This
will allow any changes in vegetation structure and
composition to be identified and evaluated against
the prescribed management. These results will help
to improve the quality of any future management
advice given.
Problems and solutions

Various problems were encountered with SRDP which restricted the number of sites gaining successful entry into RP to manage land specifically for marsh fritillary. The following practical adjustments to RP would help resolve some of these issues:

1. Applications for RP that involve SAF species (or anything akin to SAF in the future) should be deemed a National Priority. This would greatly increase the chances of a successful application if criteria and assessment processes remain the same or similar to the current system. This would also encourage a far greater uptake and interest by landowners/managers wanting to manage land for marsh fritillary.

2. Payment rates under RP for hill ground are significantly lower per hectare than that for in-bye ground. Because of this, hill ground with key marsh fritillary colonies was rarely entered into SRDP, with the consequence that these key colonies were excluded from applications, and was why comparatively few sites were entered into RP in some areas, for example, on Islay. To encourage the inclusion of hill ground in applications (for options other than bracken control), a tiered payment rate, as currently exists under the coastal heath option, would be helpful and appropriate.

3. The current scoring system is heavily weighted towards protected sites. Conservation management for marsh fritillary and other Lepidoptera is best undertaken at a landscape scale rather than on individual sites. The scheme would be more beneficial to marsh fritillary if RP favoured sites within key meta-populations rather than just protected sites.

4. Monitoring of the scheme is very limited. It is therefore unclear whether successful applicants implement the recommended management and how marsh fritillary and its habitat subsequently responds. Simple base-line and follow-up monitoring would help provide valuable information about the effectiveness of different management regimes, which would in turn improve the quality of future advice given, as well as providing crucial information about the current status of marsh fritillary in Scotland.

5. Allowing applications under a specified financial threshold to be determined using an ongoing assessment procedure, as is currently the case with forestry applications, would help resolve a number of issues encountered with the existing imposed SRDP deadlines. These included visiting and assessing sites at unsuitable times of the year and excessive workloads for the agents, case officers and Project Officer leading up to deadline dates.

6. Retrieving basic information from the SRDP website on successful RP submissions proved almost impossible despite an online application process and each field having its own field identification number (FID) and outcome plan. Having access to this basic information would allow the collation of important fundamental and very useful information such as the number of applications made and the area of land being managed specifically for marsh fritillary under RP.

Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

- The project has been very successful in delivering favourable management on the ground to benefit marsh fritillary through SRDP, and raising awareness amongst landowners and managers. This has been almost entirely due to the Project Officer taking on the role of specialist adviser and working in close partnership with landowners/managers, their agents and the case officers. The success of this relationship and delivery mechanism has also been used by others undertaking similar work on other key species, most notably great yellow bumblebee and hazel gloves fungus.

- The SAF approach, whereby action has been targeted at a short-list of key species, has worked very well for marsh fritillary. Furthermore, butterflies and moths are particularly suited to targeted action and they should be regarded as flagship species, since appropriate management to enhance their fortunes can also be beneficial to a suite of other taxa, particularly plants, birds and other invertebrates.

- The project has significantly increased the awareness of marsh fritillary and High Nature Value farming systems. SAC believe that all active land managers in Argyll are now aware of marsh fritillary. Consequently many land...
managers are specifically managing their land for marsh fritillary and are now more aware of the importance of appropriate management. The project has also opened their eyes to the presence of even common species of butterfly and moth, which they had previously simply overlooked.

- Delivery of advice at a landscape scale has also improved the species’ resilience to climate change.

**Specialist adviser**

The importance of the role of the specialist adviser should not be underestimated. It ensured that only suitable or potential marsh fritillary habitat within the range of the butterfly was entered into RP. It also ensured that the management was appropriate and deliverable at each site. The specialist adviser was able to ensure that each application was of a consistently high quality rather than applicants only doing the bare minimum by implementing generic management prescriptions. It also made the job of the SRDP case officer easier when determining the appropriateness of the proposed management regime, knowing it had come from a species expert.

**Partnership working**

By working in close partnership with agents the specialist adviser did not have to know the full workings of the SRDP and the exact details of the online application process. This meant that more time could be spent on the ground looking for marsh fritillary habitat and assessing its suitability, rather than putting full farm applications together that would inevitably include areas with little or no Lepidoptera interest. This uses the strengths of the specialist adviser to the full. Conversely the agents could focus on the rest of the farm and the application process. The success of the partnership was ultimately down to mutual trust between the farmer, agent and Project Officer.

**SRDP**

Despite the issues over RP highlighted above, other aspects, particularly the flexibility given under some of the management options, were hugely beneficial. This allowed bespoke grazing plans to be developed and deployed, resulting in deliverable site-specific applications to benefit marsh fritillary. The Management of Habitat Mosaics option was the most regularly used RP prescription, whilst the Creation and Management of Species-rich Grassland and occasionally the Coastal, Serpentine or Special Interest Heath and Management of Wetland options were also deployed. As for the majority of RP options under Axis II of the scheme, they attract an annual payment rate per hectare and last for five years, but with the rate differing for each option. The habitat mosaics option was particularly beneficial as it recognised the diversity of habitats that often occur under single management units, especially in Argyll, and that they can be managed under a single regime benefitting a range of species and biodiversity in general. This is in contrast to the old Rural Stewardship Scheme (RSS) where there was little flexibility, with each option having a standard management prescription based solely on habitat. This compartmentalised the land into small units, which are far more difficult to manage, as well as requiring excessive fencing. As a consequence site visits to old RSS schemes were often very disappointing, particularly the species-rich fields, showing that the approach of using a standard inflexible management option does not deliver the desired results on the ground.

The SRDP/RP programme is currently being reviewed and it is also unclear if anything new will evolve following on from the end of SAF in 2012. This throws a double level of uncertainty over the sustainability of the work already achieved as well as planning future work. However, it is clear that if we are to maximise the benefits of agri-environment schemes and ensure long-term sustainability for species and habitats in the wider countryside, then solutions to address these issues as well as those identified previously need to be found.

**Future recommendations**

BCS now has an excellent reputation and working relationship with case officers, advisers, landowners and managers in providing first-class specialist management advice. However, despite this success further work is required, including:

- Being more proactive in the butterfly’s core areas to identify sites where there has been no involvement.
- Establishing contact with landowners/managers/advisers in areas where there has been little or no involvement e.g. Bute.
- Reviewing management at sites already being managed for marsh fritillary under RP.
- Training volunteers to monitor sites currently being managed under RP, to provide useful feedback to BCS and the site owners/managers and their agents.
New and ongoing work since SAF ended

BCS has continued many aspects of the work on marsh fritillary post-SAF.

Survey and monitoring

A marsh fritillary monitoring workshop was held for volunteers in Oban in September 2013. The aim was to increase survey and monitoring but most importantly to ensure that future monitoring is undertaken using a standard, robust and repeatable methodology. The workshop was led by Dr Tom Brereton, BC’s Head of Monitoring, and included a field visit to Moleigh Farm to monitor fields being managed for the butterfly under RP. BCS intends to co-ordinate these volunteers and encourage them to monitor other sites being managed under RP. Due to the success of the event it is hoped to hold similar training days in the near future.

In 2014 an RSPB employee carried out monitoring of marsh fritillary at various sites across Argyll as a sabbatical project.

Management advice

BCS has continued to liaise with land managers and owners who are managing their land for the butterfly, but to a more limited extent. However, since 2011 it has become increasingly difficult for applicants to gain entry into RP. Consequently there have been very few new applications to manage land specifically for marsh fritillary since 2012. In addition the new SRDP scheme will probably not be open to applicants until 2015 and it is currently unclear whether marsh fritillary will be given sufficient priority to encourage owners to consider entering their land into RP to benefit the butterfly, or if the new payment rates will make applications economically viable. This uncertainty and the short-term nature of the scheme are not helpful and discourage many potential applicants.

Key Management Messages

- Marsh fritillary sites should be managed at a landscape scale.
- Advice should be site-specific, due to the different habitat and management regimes it is associated with in Scotland, and delivered by a specialist adviser.
- Its fortunes are closely linked to traditional agriculture and High Nature Value (HNV) farming systems.
- The butterfly has exacting habitat requirements, including abundant patches of devil’s-bit scabious, ideally in an uneven patchwork of short and tall vegetation 5–25 cm tall.
- Sites are best maintained by light grazing at 0.2–0.3 LU/ha/year either all year or with a summer grazing break.
- Grazing by traditional breeds of cattle or horses/ponies is ideal.
- Sheep can reduce and even eliminate devil’s-bit scabious from the sward and numbers should not exceed 0.2LU/ha during July to September.
- Some scrub and trees can be tolerated, however if scrub over 1 m high occupies more than 10–15% of suitable habitat it should be controlled.
- Mowing can restore under-grazed sites that are too rank and tussocky, particularly as a precursor to reinstating grazing.
- Artificial fertilizer, manure, slurry or pesticides should not be applied to sites.
- Marsh fritillary populations and their habitat can be monitored using BC’s standard methodology.
- The project’s success was due to the close working partnership between agents, land managers/owners, case officers and the Project Officer.
Publicity
The SAF marsh fritillary project has been highlighted on several occasions as an exemplar for delivering targeted management advice. BCS has highlighted this in several newsletters and articles and a recent landscape report (Ellis et al., 2012) and follow-up papers (Bourn et al., 2013).

Further Information

References


Acknowledgements

The success of this project is down to the contribution and co-operation of many individuals and organisations. First and foremost this work has only been possible through funding from BCS, FCS and SNH under SAF to enable a Project Officer to be employed to undertake the role of specialist adviser. In particular BCS would like to thank Scottish Agricultural College, Agrimony and other advisers along with the case officers for their invaluable contribution without which the successful delivery of specialist advice would not have been possible. In addition the co-operation, interest and enthusiasm of the individual landowners and managers must be praised, as well as the many volunteers who have helped provide useful local information particularly about sites and the current status of the butterfly.

Without this collaboration and support the future of marsh fritillary in Scotland would be very bleak.

The authors would also like to thank Caroline Bulman, Butterfly Conservation’s Senior Species Ecologist, for her useful comments on earlier drafts in her role as external reviewer.

The SAF Partners

- Scottish Natural Heritage
- Butterfly Conservation Scotland
- Forestry Commission Scotland
- Scottish Agricultural College

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Pearl-bordered Fritillary Butterfly

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Summary

- The pearl-bordered fritillary (*Boloria euphrosyne*) is a woodland butterfly of sheltered, sunny woodland glades and woodland edges and is one of the most rapidly declining butterflies in Britain.

- It is estimated that there are approximately 150 colonies at around 120 sites in Scotland and that these populations comprise about a quarter of the British population. However, declines in Scotland are much less than those in England and Wales, further increasing the significance of the Scottish populations.

- The main aim under the Species Action Framework (SAF) pearl-bordered fritillary project was to deliver appropriate management advice to benefit the butterfly. A steering group was formed comprising Scottish Natural Heritage (SNH), Forestry Commission Scotland (FCS) and Butterfly Conservation Scotland (BCS), who jointly funded a Project Officer to carry this out. The Project Officer’s role also included action for the two other SAF-listed *Lepidoptera*, slender scotch burnet moth (*Zygaena loti*) and marsh fritillary (*Euphydryas aurinia*), as well as the chequered skipper butterfly (*Carterocephalus palaemon*), an FCS priority species.

- The project objectives were achieved by working in close partnership with landowners and their agents and providing site-specific management advice on the butterfly to help suitable sites gain entry into the Rural Priorities (RP) scheme of the Scotland Rural Development Programme (SRDP).

- During the course of the project there was involvement at 68 sites across 18 areas, with 16 sites being managed specifically for the butterfly under SRDP. In addition management took place at a further six sites outwith SRDP, primarily through volunteer work parties and/or the owners/managers undertaking action without SRDP support.

- At the time of writing, the outcome of an application was pending or an application was still being drawn up for another 10 sites. A further 27 sites were visited but these visits did not result in any action, whilst in nine additional cases more generic advice was given without the need to visit the site.

- The success of this project is primarily due to the co-operation and goodwill of the site landowners/managers and their agents and the willingness to work together.

Introduction

Fig 1. Pearl-bordered fritillary.
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Species background

The pearl-bordered fritillary is a spring butterfly primarily of sheltered, sunny woodland glades, woodland edges and violet-rich bracken habitats (Warren, 1995). It is one of the most rapidly declining butterflies in Britain and Ireland, although the declines in Scotland are less severe than elsewhere. However, its current status in Scotland is unclear primarily because of under-recording.

The pearl-bordered fritillary’s range contracted in Britain by 61% (Fox *et al*., 2006), between two periods of butterfly recording, 1970-1982 and 1995-2004. However, the recorded decline in Scotland was much less than in England and Wales, although still cause for concern at 33%. These differing rates of decline increase the significance of the Scottish populations. In addition, at sites specifically monitored between 1976 and 2004, the fritillary’s long-term population trend in Britain showed a decline of 66% (Fox *et al*., 2006).

Unfortunately a figure for Scotland is not available as insufficient sites are monitored for the butterfly and therefore an annual Scottish index cannot be calculated.
The last national pearl-bordered fritillary survey was in 1997-98 when the Scottish population was estimated at around 150 colonies at 120 sites (Brereton, 1998). This was out of a total of just over 430 colonies at 320 sites in Britain as a whole and highlighted the significance of the Scottish populations, which made up more than a quarter of the British population. The survey also highlighted how under-recorded the butterfly is in Scotland given that over 30 of the Scottish colonies were only discovered during the survey, whilst further new colonies have been discovered in subsequent years and undoubtedly more await discovery. This under-recording is due to a number of factors, including a lack of recorders in the remoter parts of Scotland where the butterfly occurs, the short flight period of around three weeks and the difficulty of distinguishing it from the very similar, but more widespread, small pearl-bordered fritillary (Boloria selene).

The declining fortunes of this species are believed to be the result of habitat loss as well as inappropriate habitat management, coupled with the need for sufficient area and networks of habitat for the butterfly to form meta-populations, where local losses or extinctions can be reversed by recolonisation from neighbouring colonies (Barnett et al., 1995; Clarke et al., 2011).

The pearl-bordered fritillary has several localised populations across many parts of Scotland. Between 1995 and 2004 it was recorded from 119 10-km squares in Scotland, representing 40% of the British population (Fox et al., 2006). Populations are found locally in the glens of the Highlands, Grampian, Argyll, Moray and Perthshire, with an isolated population in south-west Scotland around Dumfries. As a result of the dramatic declines in the UK the pearl-bordered fritillary was listed as a UK Biodiversity Action Plan (UK BAP) Priority species, is included on the Scottish Biodiversity List, and is also identified by FCS as one of their six key woodland species targeted for action under the Scottish Forestry Strategy 2006. The butterfly is also protected from sale under the Wildlife and Countryside Act 1981 (as amended) that makes the trade of wild-caught animals illegal.

BCS has identified ten Landscape Target Areas across Scotland that highlight the country’s most important landscapes for key Lepidoptera; eight of these landscapes have important networks of pearl-bordered fritillary colonies. This helps prioritise where work on the butterfly in Scotland should be focused. It also highlights the importance of working at a landscape scale since butterfly populations are more viable if they exist within a network of functionally connected colonies (Ellis et al., 2012). Conversely fragmentation of habitat and the resulting isolation of colonies are detrimental (Barnett et al., 1995). Most sites comprise a mosaic of suitable habitat patches, although it is essential that these patches are sufficiently close and linked so that there can be an exchange of adults between neighbouring colonies. This ensures that each discrete colony can operate as part of a larger meta-population.

**General ecology**

In Scotland the pearl-bordered fritillary is a butterfly of woodland edges and the open spaces within woodlands (Ravenscroft, 1999). It has a one year life-cycle and in Scotland is usually on the wing from early May to mid-June. It requires sunny, sheltered sites, normally south-facing hillsides, as both the adult butterfly and its caterpillar require a very warm micro-climate.

The butterfly’s sole larval foodplant is common dog-violet (Viola riviniana), although occasionally marsh violet (Viola palustris) is used. Favoured sites also tend to have short vegetation and light to moderate bracken (Pteridium aquilinum) cover which are both vital for providing additional warmth. The female butterflies usually lay their eggs on a range of substrates including bracken, grass stems and leaves of other plants singly adjacent to rather than on the larval foodplant.
The eggs hatch within a fortnight and the small caterpillars grow slowly feeding in spells of warm weather. In September they start to hibernate, sheltered within or under the bracken litter layer, re-emerging usually on the first sunny days of March. It is at this stage that the black caterpillars bask on the dead and dry bracken litter to raise their body temperature, before they can become active and feed and digest their food. Occasionally leaf litter, rock and bare ground are used as a substitute for the bracken but there are probably only a handful of occupied colonies in Scotland that are not reliant upon bracken. The caterpillars continue to feed until the second half of April or the beginning of May, when they pupate on the ground amongst the bracken litter, before emerging as adults two to three weeks later.

The adult butterflies are only active in warm or sunny weather and in Scotland are usually on the wing from the middle of May until the middle of June. However, their flight period can vary by around three weeks between years and between sites, hence in early springs they can be on the wing in late April whilst at upland sites they may still be on the wing in mid-July. Males often glide low over the ground patrolling for females. Both sexes are regularly encountered at nectar plants, especially bugle (Ajuga reptans), particularly plants in sunny and sheltered locations. Other favoured nectar plants include dandelion (Taraxacum officinale agg.), bluebell (Hyacinthoides non-scripta) and bird’s-foot trefoil (Lotus corniculatus).

Habitat management

The main aim of management for pearl-bordered fritillary at most sites is to prevent bracken from becoming too dense and the bracken litter too deep thereby shading-out violets, whilst also ensuring that tree regeneration does not encroach on suitable habitat. Light cattle grazing can be very beneficial in keeping areas flower-rich and maintaining bracken in suitable condition by reducing its density and preventing the build-up of excessive litter through trampling and disturbance. Low levels of deer browsing can be particularly important at preventing excessive scrub encroachment. However, at many sites the introduction of livestock grazing is unfeasible and impractical, and some form of bracken management is required to reduce the vigour of the bracken, rather than eliminate it. This can be achieved by bruising, rolling or mechanical cutting if the site is accessible to machinery. Smaller and/or less accessible sites are best controlled by applications of herbicide, particularly Asulox, using a knapsack or ULVA sprayer. However, it is more effective on larger sites to undertake aerial spraying by helicopter. The current European ban on Asulam, therefore,
poses an additional and significant threat to the future management of pearl-bordered fritillary sites. Bracken control can often lead to a temporary explosion in pearl-bordered fritillary populations. This is probably due to violets responding favourably to the increased light levels and the continued presence of bracken litter and dead fronds. At most sites the bracken re-establishes and the population returns to a more typical level, but if bracken is eradicated then populations will slowly decline and become extinct. This emphasises the dynamic nature of pearl-bordered fritillary populations and the need to plan management carefully over time.

Because of differences between sites, an individual bracken control and grazing plan is required to take account of the local deer population and specific factors at each site. In addition the maintenance of open space within woodlands is vital in preserving the connectivity between colonies. In many cases the links have to be created or re-established to make a site more ‘porous’ to the butterfly. This can be achieved through the removal of blockages, for example by felling plantations, clearing scrub, creating sunny glades and rides and/or paths. Ideally, if the ride is wide or long enough, the clearance of scrub should be staggered to produce open space at different stages of succession. It is best practice for rides and paths to run east-west as they have a greater proportion of warmer south-facing edges and the inclusion of scalloped bays at intervals along the south-facing edge will also provide additional sheltered sunny habitat. Utility wayleaves through woodland often support pearl-bordered fritillary colonies providing suitable sheltered, open habitat, and their linear nature means that they can act as corridors to link neighbouring colonies (Ravenscroft, 2006).

A colour leaflet Learn About the Pearl-bordered Fritillary was also produced, aimed at recorders as well as land managers and their agents. It provided useful information on the butterfly’s lifecycle, identification, ecology and habitat management requirements in Scotland.

Aims

Aims and objectives for 2007-2012

The overall aim of the SAF pearl-bordered fritillary project was to influence land management to enhance habitat for pearl-bordered fritillary, rather than undertake research, survey and/or monitoring. The key objectives of the project were to:

• Maintain the core range of the species across Scotland.
• Increase the viability of all networks by increasing the extent of suitable habitat and enhancing links between sub-populations.
• Raise awareness and appreciation of pearl-bordered fritillary with land owners/managers/advisers.

Management Action

Summary of the main actions carried out

The objectives were achieved by:

• Specialist adviser – a Project Officer was employed to provide specialist advice.
• Bringing land management into SRDP Rural Priorities – the Project Officer assisted landowners/managers, through their agents, to gain entry into Rural Priorities (RP) and ensure appropriate management at suitable sites.
• Specific management activities – these included woodland grazing, bracken and scrub control, and fencing.
• Awareness raising – through updating and reprinting BCS’s colour leaflet Learn About the Pearl-bordered Fritillary, the production of an FCS species action note and an FCS technical note, and by giving talks and press articles.

Action before the Species Action Framework

Prior to the introduction of SAF, BCS had organised a number of events across Scotland to raise the profile and awareness of moths and butterflies including pearl-bordered fritillary. This included:

• Recruiting local volunteers to encourage recording of pearl-bordered fritillary and other species.
• Demonstration days to highlight the butterfly’s habitat and management requirements, particularly the benefits of woodland grazing, to land owners/managers, advisors and government officials.
Steering Group and Project Officer

A steering group was formed in 2008 comprising SNH, FCS and BCS. This group jointly funded a Project Officer, employed by BCS, to encourage appropriate action on the ground for pearl-bordered fritillary. The Project Officer’s role also included action for the two other SAF-listed Lepidoptera, marsh fritillary and slender scotch burnet moth, and for chequered skipper, a woodland butterfly that is listed as a priority species on the FCS Scottish Forestry Strategy along with pearl-bordered fritillary. The group met once or twice a year to review the work undertaken and to help steer future work on all four species.

Initial plans

The original intention of the project was to target management advice to benefit pearl-bordered fritillary at sites within eight Landscape Target Areas identified by BCS that hold significant populations of the butterfly. However, this was not as straightforward as initially expected mainly because it was difficult (often because of the restrictions set out in the Data Protection Act) to find out who owned or managed the sites where the butterfly had been recorded. This proved to be very frustrating.

Following the marsh fritillary blueprint

Similar work under the SAF marsh fritillary project was successful in delivering land management advice by working in partnership with farmers and land owners through their agents. This resulted in the Project Officer taking on the role of specialist adviser in assisting and encouraging entrants to gain access into the competitive SRDP RP scheme, to manage land specifically for the butterfly. Given the success with marsh fritillary a similar approach was adopted for pearl-bordered fritillary.

Woodland SRDP issues

The successes achieved on the agri-environment side of SRDP for marsh fritillary and slender scotch burnet moth proved far more difficult to replicate for pearl-bordered fritillary under the forestry element. There were a number of reasons for this.

1. The initial payment rates under SRDP for many of the woodland management options were considered too low to be financially viable and therefore there was very little uptake or interest.

2. One of the requirements under RP woodland management was the need for a long-term forest plan, which is both costly and off-putting for land owners.

3. Pearl-bordered fritillary has a much wider distribution in Scotland than the other two SAF Lepidoptera species. This meant working across a wider geographical area and with many different agents, rather than with just the two Argyll agents’ companies that dealt with marsh fritillary and slender scotch burnet. It also proved very difficult to identify and engage with the appropriate agents working in many of these areas.

4. In most cases woodland schemes cover larger areas of ground and longer timescales than agricultural ones. There is therefore far less opportunity to enter land into new schemes, as much of it is already being managed under an existing scheme.

5. Issues arose with those sites being managed under the Farm Woodland Premium Scheme (FWPS). Several sites for the butterfly were still being managed under this former scheme that encouraged landowners to exclude livestock from woodlands, in most cases for a period of 35 years. In the long-term this can be detrimental to pearl-bordered fritillary allowing excessive scrub, bracken and coarse vegetation to develop (Ravenscroft, 1998). Despite general agreement that these sites would greatly benefit from the reintroduction of suitable livestock grazing, this was not permissible until the FWPS had expired, which for many sites was in 8-12 years time.

In addition to issues with SRDP it can be very hard to assess the suitability and condition of pearl-bordered fritillary habitat between July and February, as it is difficult to walk through tall bracken and check for the presence of the larval foodplant. In 2010 and 2011 the March to June window, when assessment would have been possible, was further shortened because of snow.
Overcoming the issues

In order to overcome the difficulties of getting woodland management done for pearl-bordered fritillary the following actions were undertaken.

1. All SRDP woodland case officers were reminded about the SAF project and the Project Officer’s specific role to assist landowners and their agents with woodland SRDP applications to favour pearl-bordered fritillary and chequered skipper. Case officers were encouraged to consult with the Project Officer on any applications in the core areas of both woodland butterflies to ensure that the proposed management would be beneficial.

2. Training days were held for FCS case officers to promote the project and outline the habitat and management requirements of pearl-bordered fritillary.

3. A web-based technical note was produced by FCS, aimed at landowners, managers and their agents who were considering woodland management for pearl-bordered fritillary. It provided information on the most suitable management to benefit the butterfly and how this management might be achieved and assessed under SRDP.

4. Because of the short window when it is possible to assess habitat condition for pearl-bordered fritillary, a simple, rapid survey method was

Table 1. Summary outlining the number of sites where advice has been given per area for pearl-bordered fritillary up to 2011.

<table>
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<tr>
<th>Area</th>
<th>Approved SRDP</th>
<th>Pending SRDP</th>
<th>Management Non-SRDP</th>
<th>Visited</th>
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<td><strong>10</strong></td>
<td><strong>6</strong></td>
<td><strong>27</strong></td>
<td><strong>9</strong></td>
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</table>
developed for volunteers and contractors to help identify suitable habitat and areas requiring management. This methodology was deployed at a number of locations, often in conjunction with FCS, for sites on the National Forest Estate (NFE).

5. Controlled woodland grazing is an SRDP option that only became available in 2011. It provided considerable potential to benefit pearl-bordered fritillary. Under this option it became possible to graze woodlands to enhance the habitat for pearl-bordered fritillary and other open-woodland species, including chequered skipper. The Project Officer attended the three launch seminars, at Blair Atholl, Benderloch and Drumnadrochit, to highlight how woodland grazing can benefit butterflies as well as to promote the SAF project, particularly the delivery of free advice to benefit the butterfly.

Results

Table 1 summarises the activity on pearl-bordered fritillary during this project. It shows that the Project Officer was involved at 68 sites across 18 areas, with 16 sites being managed specifically for the butterfly under SRDP. In addition management has taken place at a further six sites outwith SRDP, primarily through volunteer work parties and/or the owners/managers undertaking action without SRDP support. The outcome of an application was pending or an application was still being drawn up for a further 10 sites at the time of writing. A further 27 sites were visited but these did not result in any action, whilst in nine additional cases more generic advice was given without the need to visit the site. All sites in Table 1 are plotted alongside the Scottish distribution of pearl-bordered fritillary (1980-2009) in Fig. 5.

In addition habitat assessments were undertaken in four areas highlighted in bold in Table 1. In the Trossachs and Easter Ross this was almost exclusively on the National Forest Estate, whereas in Highland Perthshire and Deeside the majority of sites were in private ownership. Unfortunately it is not currently possible to determine the number of different ownerships that the surveys in the latter two areas covered and therefore these have not been added to the totals in the table.

Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

The SAF approach, through which action has been targeted at a short-list of key species, has worked very well for Lepidoptera. This is primarily because the three species selected were carefully chosen and thus ideal candidates, as threatened species with fairly well understood ecology and management requirements. Furthermore, butterflies and moths are particularly suited to targeted action and should be regarded as flagship species, since appropriate management to enhance their fortunes will also be beneficial to a suite of other species, notably plants, birds, reptiles and other invertebrates. The project has successfully increased awareness of pearl-bordered fritillary as well as the biodiversity benefits of woodland grazing.
Specialist adviser

The importance of the role of the specialist adviser should not be underestimated. This ensured that only suitable or potential pearl-bordered fritillary habitat within the range of the butterfly was entered into RP. It also ensured that the management was appropriate and deliverable at each site. The specialist adviser was able to ensure that each application was of a consistently high quality rather than applicants only doing the bare minimum and implementing generic management prescriptions. This also made the job of the SRDP Case Officer easier when determining the appropriateness of the proposed management regime, knowing it had come from a species expert.

The project has been successful in delivering management advice for pearl-bordered fritillary and for this to be implemented, mainly via SRDP. However, it is becoming increasingly difficult for applicants to gain entry into SRDP. This uncertainty is not helpful in trying to continue the project and deliver further management advice.

Survey and monitoring

An aspect that was missing from, and would have greatly enhanced the benefits of, the project was the ability to undertake surveys and carry out monitoring. Pearl-bordered fritillary is under-recorded in Scotland and having a base-line survey to determine its current distribution and status would have been invaluable. Furthermore these tasks could have easily been undertaken by trained volunteers thereby considerably adding value to the project.

It would be very useful to have a greater input from trained volunteers who could provide useful feedback to both the Project Officer and the landowner/manager. This could be achieved by recruiting and training volunteers to:

• Undertake surveys to look for the butterfly especially in under-recorded areas.
• Identify areas of potential/suitable habitat.
• Undertake initial habitat assessments.
• Repeat these habitat assessments to help determine the effect of management.
• Undertake long-term monitoring of targeted pearl-bordered fritillary populations, in order to assess whether the management is working.

Fortunately in 2012 FCS commenced a monitoring programme at around twenty sites for pearl-bordered fritillary on the National Forest Estate. The aim is that this will allow a Scottish national index for the butterfly to be calculated annually for the first time. This will allow the fortunes of different populations across Scotland and elsewhere to be compared. The data will also be used to investigate the impacts of management on the butterfly.

Partnership working

By working in partnership with agents, the specialist adviser did not have to know the full workings of the SRDP and the exact details of the online application process. This meant that more time could be spent on the ground looking for and assessing habitat suitability, rather than putting complete woodland applications together. This used the strengths of the specialist adviser to the full whilst the agents could focus on other aspects of woodland management and the application process.

BCS now has an excellent reputation and working relationship with case officers, advisers, landowners and managers in providing first class specialist management advice.

Future recommendations

The significant successes that have been achieved under SAF for each of the Lepidoptera species should just be seen as a start to what is possible.

Further recommendations for work focussing on pearl-bordered fritillary include:

• Continuing liaison with owners and their advisers at key sites that are yet to be managed under SRDP, for example Creagan Wood in Argyll and Creag Dubh in Badenoch and Strathspey.
• Making proactive approaches to landowners in the four areas where habitat assessments have been undertaken, and to identify sites in the butterfly’s core areas where there has so far been little or no involvement.
• Improving the promotion of management advice to woodland owners/managers through increasing the profile of the project.
• Reviewing existing management at sites already being managed for pearl-bordered fritillary under RP, and establishing monitoring, primarily by trained volunteers, of both the habitat and the butterfly to provide feedback to owners and advisers. This is in addition to using the results to help better inform future advice.
In addition there is scope for the project to provide advice on a handful of other equally scarce and threatened woodland Lepidoptera species, whose habitat requirements are suitably well known to allow effective management advice to be provided. This would include continuing to work on chequered skipper but also other woodland species such as Kentish glory (*Endromis versicolora*) and dark bordered beauty (*Epione vespertaria*).

**New and ongoing work since SAF ended**

BCS has continued many aspects of the work on pearl-bordered fritillary since SAF finished, with financial support from SNH and FCS.

**Survey and monitoring**

A species distribution model for both chequered skipper and pearl-bordered fritillary in Scotland was developed in conjunction with Dr Stuart Ball of the Joint Nature Conservation Committee. It used the current distribution of the butterfly in Scotland at 1 km resolution to select background data to train the model. The most important factors that influenced the accuracy of the model for pearl-bordered fritillary were, as might be expected, the presence of south-facing slopes and woodland cover, followed by factors relating to water and temperature. The model for chequered skipper was subsequently tested by BCS encouraging volunteers in 2012 and 2013 to look for the butterfly in the top 100 1-km squares predicted by the model to be the most suitable for the butterfly, but where it had not previously been recorded. Over the two years the butterfly was recorded in 42% of the 47 different 1-km squares visited, as well as an additional 48 new 1-km squares, highlighting how under-recorded the chequered skipper is in Scotland. The model for pearl-bordered fritillary has not been field-tested but the initial results from the chequered skipper surveys give hope that it may be a useful tool in identifying the location of new colonies and thus gaining a better picture of the butterfly’s true distribution.

BCS, in partnership with FCS, developed a detailed sampling strategy for both chequered skipper and pearl-bordered fritillary. This involved identifying a target of 25 widely scattered pearl-bordered fritillary sites that would need to be monitored by a combination of single-species transects, multi-species transects and timed counts, in order to:

1. Enable a robust national (Scottish) trend to be calculated for pearl-bordered fritillary on the NFE.
2. Enable a comparison of performance between NFE land and the rest of the UK.
3. Across the range of the butterfly (>10% of the national distribution was sampled).
4. Across the known range on NFE holdings (~40% coverage at 1-km square resolution).
5. By habitat type.
6. By population size category.
7. As a result 47 pearl-bordered fritillary sites located in 45 1-km squares were sampled in 2012, thereby exceeding the target by 22 sites (188%). This high level of coverage was achieved by careful targeting of monitoring sites using both skilled local contractors and local volunteers. The monitoring also achieved good sample coverage:

1. **By** population size category.

The monitoring was repeated in 2013 exceeding the previous year’s coverage and it is hoped that this monitoring will continue to be undertaken annually.

**Management advice**

BCS has continued to liaise with land managers and owners who are managing their land for the butterfly, but to a more limited extent. However, since 2011 it has become increasingly difficult for applicants to gain entry into RP. Consequently there have been very few new applications to manage land specifically for pearl-bordered fritillary since 2012. Nevertheless, important colonies at Creagan in Argyll and Creag Dubh in Badenoch and Strathspey are now both being managed through SRDP under the Sustainable Management of Forests – Woodland Grazing option. The requirement of appropriate bracken management to benefit pearl-bordered fritillary was also highlighted at a series of bracken demonstration days hosted by SAC consulting.

The new SRDP scheme will probably not be open to applicants until 2015 and it is currently unclear whether pearl-bordered fritillary will be given sufficient priority to encourage owners to consider entering their land into RP to benefit the butterfly, or if the new payment rates will make applications economically viable. This uncertainty and the short-term nature of the scheme are not helpful and discourage many potential applicants.
Further Information


Key Management Messages

- Pearl-bordered fritillary sites should be managed at a landscape scale.
- Advice should be site-specific and delivered by a specialist adviser.
- The butterfly’s fortunes are closely linked to traditional agriculture and High Nature Value (HNV) farming systems.
- The larvae only feed on violets and require a warm micro-climate. This is usually provided by light to moderate bracken cover on steep slopes in sunny and sheltered conditions.
- The adult butterfly benefits from areas rich in nectar.
- The main aim of management is to prevent violets being shaded-out by excessive tree regeneration, or the bracken from becoming too dense and/or its litter too deep.
- At many sites some form of bracken management is required to reduce its vigour rather than eliminate it. This can be achieved by bruising, rolling, cutting or applications of herbicide, particularly Asulox.
- Light cattle grazing can be beneficial in keeping areas flower-rich and maintaining bracken in suitable condition through trampling and disturbance. Low-levels of deer browsing can also be important.
- The maintenance of open space within woodlands is vital in preserving connectivity between colonies. Rides/wayleaves/paths should be 1.0 - 1.5 times wider than the height of the adjacent trees; east-west rides/wayleaves/paths have a warmer south-facing edge, and creating scalloped bays at intervals along this edge provides additional sunny habitat.
- Pearl-bordered fritillary populations and their habitat can be monitored using BC’s standard methodology.
- The project’s success was due to the close working partnership between agents, land managers/owners, case officers and the Project Officer.
References


Acknowledgements

The success of this project is solely down to the contribution and co-operation of many individuals and organisations. First and foremost this work has only been possible through funding from BCS, FCS and SNH under SAF to enable a Project Officer to be employed to undertake the role of specialist adviser. In addition the co-operation, interest and enthusiasm of the individual landowners and managers must be praised.

Without this collaboration and support the future of pearl-bordered fritillary would be very bleak.

The authors would also like to thank Martin Wain, Butterfly Conservation’s Northern England Conservation Officer, for his useful comments on earlier drafts in his role as external reviewer.

The SAF partners

- Scottish Natural Heritage
- Butterfly Conservation Scotland
- Forestry Commission Scotland

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Pearl-bordered fritillary identification

The pearl-bordered fritillary is one of four fritillary butterflies that occur in Scotland. Given a good view, the dark green fritillary and the marsh fritillary are readily distinguishable but the pearl-bordered fritillary is easily confused with the small pearl-bordered fritillary, a widespread and often common butterfly in parts of Scotland.

The key features for distinguishing between these two species are flight period and the pattern on the underside of the hindwing. Despite their names there is very little difference in size, so this is an unreliable feature. It is recommended that a butterfly net is used to gain a close look at the features described above. In most cases an individual can be identified from reasonable photographs, particularly of the underwings.

Table 2: Pearl-bordered fritillary vs. small pearl-bordered fritillary identification

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pearl-bordered fritillary</th>
<th>Small pearl-bordered fritillary</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markings on underside of hindwing (see Figs. 6 and 7 below)</td>
<td>Small black dot. 2 ‘white cells’.</td>
<td>Large black dot. 7 ‘white cells’.</td>
<td>White cells may not all look completely white, especially in worn individuals.</td>
</tr>
<tr>
<td>Flight period</td>
<td>Early May to mid June.</td>
<td>Late May to late July.</td>
<td>Overlap in flight periods late May to mid-June.</td>
</tr>
<tr>
<td>Habitat</td>
<td>Dry, woodland glades/ edges often on south-facing hillsides. Caterpillars feed predominately on dog violet but can use marsh violet.</td>
<td>Wet open moorland, damp grassland/ woodland. Caterpillars feed on marsh violet.</td>
<td>Habitat requirements often exist side-by-side at same site.</td>
</tr>
</tbody>
</table>

Figs 6 and 7. Underside of hindwings of pearl-bordered (left) and small pearl-bordered fritillary (right) showing the key identification features.

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This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to [www.snh.gov.uk/speciesactionframework](http://www.snh.gov.uk/speciesactionframework)

Pine Hoverfly

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Summary

- The pine hoverfly, *Blera fallax* (Diptera, Syrphidae), is restricted to just two sites in Scotland: Curr Wood and Anagach Wood (Fig. 1). It was identified as a priority species under the UK Biodiversity Action Plan (UKBAP) and is listed in the UK Red Data Book as category 1 (Endangered). The main aim of the Species Action Framework (SAF) project was to restore the pine hoverfly from two to five historical localities by 2012.

- Under the UK Species Action Plan, the Royal Society for the Protection of Birds (RSPB) and the Malloch Society had formed a pine hoverfly steering group, which was expanded for the SAF project to include Forestry Commission Scotland (FCS). In 2007, this steering group appointed a Project Officer, to complete the actions identified for the SAF project.

- Comprehensive surveys were carried out to confirm the status of the pine hoverfly, and habitat creation and captive-rearing techniques were developed. Three suitable sites were located within the species’ historic range and, through correspondence and consultation with landowners and managers, breeding habitat was created in preparation for translocation.

- In 2009, 179 captive-bred pine hoverflies were released in Rothiemurchus Estate, a site within their historical distribution. Forty-three pine hoverfly larvae were subsequently found in artificial breeding habitat created at the release site, and up to 1 km from there. With promising initial results, the process was repeated in 2010 at Abernethy Forest and 2011 at Inshriach Forest, the success of which is yet to be determined.

- During the preparation of sites for translocation, pine hoverflies from captive breeding in the first year were used to develop microsatellite markers to assess the genetic health of the Scottish population (by comparison with a population in Sweden). The findings suggested that the two Scottish populations were genetically distinct, and both had gone through a recent population bottleneck, which may have a deleterious effect on fitness. Methods were also developed for non-invasive extraction of DNA from pupae to monitor the Scottish population, and to further test populations for potential translocations from the Continent in the future.

- Experiments monitoring pine hoverfly larval growth in competitive conditions and different rot-hole environments suggest that competition for resources may limit adult size. However, different species of hoverfly inhabiting Scots pine rot-holes seem to differ in their utilisation of the habitat, and are therefore not likely to affect recovery of the pine hoverfly.

- These findings on the biology, life strategies and techniques for monitoring the genetic health of the pine hoverfly have been combined to develop protocols for on-going conservation management.

- The pine hoverfly is a relic of our ancient, boreal, Caledonian pine forest, which is now restricted in Britain and Ireland to Scotland, as relatively small fragments. Our appreciation of its importance is exemplified by the enthusiastic participation of numerous organisations, private landowners and managers throughout the course of the SAF project.

Introduction

The pine hoverfly (*Blera fallax*) is a hairy, mainly black species with a bright, red-tipped abdomen and a yellow face. It has a wingspan of 8.0–9.5 mm and resembles a small bumblebee.

Why was this species on the Species Action List?

The pine hoverfly met criterion 1a of the Species Action Framework, as a species for conservation action (SNH, 2007). It was restricted in the UK to only two sites in the central Scottish Highlands; there had been a documented decline in numbers and distribution since the early 20th century; population levels at the two remaining sites were low; and it remained under threat of extinction. There was sufficient knowledge of the species’ habitat requirements for targeted action to be taken to help the species recover. It was a UKBAP Priority Species and is included on the Scottish Biodiversity List. It is also considered to be declining and under threat in Europe.
Habitat, distribution and abundance

In Scotland the pine hoverfly is associated with mature Scots pine (*Pinus sylvestris*) although in Europe it also occurs in association with other conifer species. Most historical records refer to native pinewood sites but the modern records are more closely linked to mature plantations where forestry operations are taking place. Despite at least 10 years of survey work only two remaining populations are known, both of which occur in Strathspey in the north-western Cairngorms, centred on the area between Aviemore and Grantown-on-Spey (Fig. 1). In historical times this species was recorded from Deeside (eastern Cairngorms), along the River Findhorn and in several other parts of Strathspey.

![Fig 1. Extant pine hoverfly sites, Curr and Anagach woods, and translocation sites, Rothiemurchus Estate, Abernethy Forest (including Dell Wood, not currently a site suitable for translocation), and Inshriach Forest. © Googlemaps](image)

General ecology

Pine hoverfly larvae develop in wet situations in pine stumps, usually where there has been some softening or decay of the heartwood by the pine butt-rot fungus (*Phaeolus schweinitzi*). The pine stump needs to have a diameter greater than 40 cm in order to support a large enough wet decay area. The larvae can emerge as adults after only one year if conditions are suitable, but if conditions are not so because of a small area of decay or overcrowding they may remain as larvae for at least two years. The larvae leave the decay to pupate around the margin of the stump or in surrounding undergrowth. Each fresh stump can probably support the appropriate decay for a period of 8-10 years before the stump dries out completely; therefore a continuity of stumps is required. In a natural situation it is considered that pine hoverfly larvae would develop in the stumps of large pines which, weakened by an attack of the butt-rot fungus, would snap off during storms. However, given the lack of extensive areas of large, old pines in Scotland where this process could take place naturally, the species relies, perhaps almost entirely, on stumps cut as part of forestry operations. Evidence from Norway and Finland supports this position. Adults have been seen feeding on flowers of raspberry, but little else is known about their behaviour or dispersive abilities.

History of decline, contributory factors and current threats

The pine hoverfly was first known in Britain in the late 19th century when a Victorian collector found the first specimen buzzing at his hotel window in Braemar. There were occasional records up until the 1940s, but then a marked gap in the latter part of the 20th century apart from the discovery of a number of individuals, presumed to be from one breeding stump, in the 1980s. After some ten years of searching, larvae of the hoverfly were eventually found in Scotland in the late 1990s, and the understanding of the conditions which they required for development prompted a widespread survey for further sites. Despite this, only two sites are currently known.

There is no current threat to the populations in the conventional sense; the main issue is that at present our pinewoods do not have the extent of mature or over-mature pines which this species requires. Ironically, felling within native pinewoods during the early 20th century probably meant that pine hoverfly populations remained high; conservation efforts in recent decades have stopped this felling, but with a consequential negative impact on the species. The other important factor is that present population levels are considered so low
and localised that any large scale colonisation events into surrounding appropriate habitat may be unlikely.

**Aims**

**Aims for 2007-2012**

The SAF project for pine hoverfly worked towards the following three objectives:

- Maintain viable populations at the two currently occupied sites.
- Increase the amount of suitable breeding habitat and populations at currently occupied sites to increase the potential for further colonisation.
- Achieve an increase in the range to five sites by 2012.

Several actions were identified:

- Develop partnership with the site owners and other forestry interests in Strathspey, to promote appropriate management of existing and potential new sites.
- Prepare a guidance note on habitat management for the pine hoverfly.
- Boost populations on current sites using suitable management techniques to a level where colonisation of new sites might occur.
- Continue to develop techniques for artificial breeding sites, and use to monitor for the presence of the species elsewhere.
- Monitor the effectiveness of the actions in order to refine future management.

**Habitat creation**

Following successful techniques of habitat creation for the hoverfly *Callicera rufa*, which also inhabits pine rot-holes (MacGowan, 1994), we created rot-holes by boring holes into the centre of stumps left after felling, using either a chainsaw or a drill (see text box below), thereby mimicking the rotting process (Fig. 2).

![Fig 2. Bored rot-holes created using a chainsaw (left) and by drilling into the heartwood (right).](image)

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Artificial breeding habitat was previously created within a 10 ha area in one of the extant sites for the pine hoverfly, Curr Wood (Fig. 1) in 2003, where 42 rot-holes were bored using a chainsaw. From 2007 to 2009, an additional 92 chainsaw-bored holes were created within the same area, and in June 2011 these were supplemented with 50 drill-bored holes (Table 1).

### Methods for creating habitat

**Using a chainsaw**, holes were created by making two parallel 15 cm-deep cuts straight down into the surface of the stump. These were positioned either side of the heartwood centre roughly 15–20 cm apart. Two further cuts were made perpendicular to and connecting the initial cuts to complete a square on the surface. These were made at 45° angles into the centre of the stump to join at a point about 15 cm deep thus cutting out a triangular wedge. The hole was filled with either sawdust (untreated from a local sawmill) or wood-chips, or sawdust and chips, and the triangular wedge was used to partially cover the hole to protect the content from evaporation while allowing rainwater to fill the cavity.

**Using a petrol-powered drill and 25 mm auger bit**, roughly 10 cm diameter circular holes were created by boring repeatedly into the centre of the stump, resulting in a 15 cm-deep cavity occupying the heartwood. Sawdust created by the drilling process was used to fill the hole, and thick bark was used to partially cover the cavity.

In 2008, 25 holes were cut in stumps in the second extant site, Anagach Wood (Fig. 1), using a chainsaw and filled with pine wood-chips (Table 1). These were within a 10 ha area and were created near locations where the pine hoverfly had been recorded previously.

### Habitat surveys

At Curr Wood, emergence traps were positioned over 104 seemingly suitable rotting stumps, and a 3 km transect was surveyed at least daily between May and July 2008. A total of six adults were caught in traps and marked on the thorax with nontoxic enamel paint, and two ovipositing females were caught and marked at stumps, but no adults were re-sighted.

Fourteen rot-hole surveys were carried out at Curr and Anagach woods between November 2007 and February 2011. The detritus content of chainsaw-bored rot-holes, plastic pots, and stumps with natural heart-rot was searched for pine hoverfly presence.

**Curr Wood**

Each year from 2007 to 2011 the chainsaw-bored rot-holes, and two stumps with natural heart-rot, were searched for pine hoverfly presence. All other naturally rotted holes (28) were too difficult to access because of their depth and small openings, and the remaining bored stumps (47%) did not retain water.

**Anagach Wood**

Of c. 200 Scots pine stumps searched in Anagach Wood, 10 had naturally rotted holes that retained water. No pine hoverfly larvae or puparia were found in any breeding habitat, artificially created or natural, in Anagach Wood.

### Table 1. Artificial habitat created at six sites over eight years.

<table>
<thead>
<tr>
<th>Site</th>
<th>2003</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curr Wood</td>
<td>42</td>
<td>17</td>
<td>15</td>
<td>60</td>
<td>50</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td>Anagach Wood</td>
<td>10</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Rothiemurchus Estate</td>
<td>18</td>
<td>76</td>
<td></td>
<td></td>
<td>30</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>Abernethy (RSPB)</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td>10</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>Dell Wood (SNH)</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Inshriach (FCS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>160</td>
<td>160</td>
<td></td>
</tr>
</tbody>
</table>
Captive breeding for translocation

In October 2008, a survey identified 100 pine hoverfly larvae in the artificially created rot-holes at Curr Wood. Because this was probably a small fraction of the actual population size based on the amount of available naturally rotted habitat, we removed 50 larvae for captive breeding in the laboratory. From this initial sample, more than 1,200 larvae were bred in captivity, of which 430 have been released at translocation sites and the source site (Table 2).

Competition in Scots pine rot-holes

Experiments were conducted to study how larvae respond to substrate conditions and intra-specific competition effects (Rotheray, 2012). Behavioural observations were also made to inform rearing and habitat creation techniques, as well as to investigate microhabitat use and life history (Rotheray, 2013). The composition of fill material within the rot-hole and the number of other larvae present can both affect pine hoverfly larval growth, which has consequences for adult size. The experiments suggest that optimal growth requires a minimum of 40 ml of pine sawdust (or chips and sawdust) and 70 ml of spring water per larva (Rotheray, 2012).

Rearing larvae

Larvae were transferred individually to 1 l glass-bottle microcosms, which were designed to simulate rot-holes. A mix of pine sawdust, chips and spring water was allotted to each bottle based on observation of rot-holes in the field. Larvae were kept in climate-controlled facilities with thermal conditions that mimicked those experienced in the field in Strathspey, estimated using on-site data-loggers and Met Office reports. However, to avoid mortality due to freezing of the water in the microcosms, temperatures were kept above 1°C. Bark pieces were provided to allow larvae to crawl out of the water, or approach the surface to breathe, as well as moss plugs at the top of the microcosm, which fully developed larvae require for overwintering or pupation (Rotheray, 2012).

Upon emergence, all adults were kept in captivity in 2009 (19 males and 19 females), and in subsequent years a random selection of individuals were kept for captive rearing (15 males and 24 females in 2010, 30 males and 30 females in 2011) while the rest were released at the translocation site. Those kept for captive breeding were moved into breeding cages.

Adult flight cages

Two types of cage were tested: one large outdoor cage positioned on-site at the release location, where an observer could enter to record adult behaviour and time budgets in a close-to-natural situation; and four small indoor cages that provided better control over light and temperature and were used primarily to observe mating and

<table>
<thead>
<tr>
<th>Site</th>
<th>Owner/manager</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Curr Wood</td>
<td>Private</td>
<td>35</td>
<td>109</td>
<td>142</td>
<td>0</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10(5/5)*</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24(8/16)*</td>
</tr>
<tr>
<td>Anagach Wood</td>
<td>Community owned</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Rothiemurchus Estate</td>
<td>Private</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>84(L)</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>95(50/45)*</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48(24/33)*</td>
</tr>
<tr>
<td>Abernethy Forest</td>
<td>RSPB</td>
<td>–</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>51(L)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>78(30/48)*</td>
</tr>
<tr>
<td>Inshriach Forest</td>
<td>FCS</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40(L)</td>
</tr>
</tbody>
</table>

Table 2. Survey results reporting total larval abundance per year at each site (N), and number of adults released (between May and July) or larvae (L) released (between September and October) at each site (R).
oviposition behaviour (Fig. 3). A range of food-plants were presented to adults in both types of cages based on what was available in and around Curr Wood. They were collected from the field and positioned in bottles filled with water, plugged with netting to prevent individuals from falling in. Cotton wool soaked in dilute honey solution provided an additional nectar source.

Adults were on the wing, in captivity, from 11 May until 24 August, and males and females had a mean lifespan of 38 and 34 days, respectively (Table 3). In total, 44% and 43% of the day (between 08.00 and 20.00 hrs BST in good weather conditions) were spent feeding and resting, respectively. Individuals were most often observed resting on the walls and roof of the netting. Adult pine hoverflies fed on rowan (66%), greater stitchwort (27%), umbellifers (23%), bedstraws (2%), dog rose (<1%), and buttercups (<1%). In indoor cages, adults spent most of their time on the roof of the cage at the closest point to the light source. Flowers had to be positioned near this area in order for adults to land on them and feed. Water was imbibed only when the netting near the top of the cage was sprayed.

**Mating requirements**

Males aged 11 days and females aged 15 days were observed mating in the indoor cages (Table 3). Moving individuals between cages led to a cessation of mating attempts for several days. Therefore, to encourage as much mating as possible, the remaining individuals were divided

---

**Table 3. Details of pine hoverfly life history, fecundity and oviposition, and larval and adult rearing requirements.**

<table>
<thead>
<tr>
<th>Life History</th>
<th>Dates</th>
<th>Days</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time from oviposition to 1st visible instar</td>
<td>24th June to 15th July</td>
<td>21</td>
<td>194</td>
</tr>
<tr>
<td>Time from visible instar to final instar</td>
<td>24th June to 16th June</td>
<td>326</td>
<td>28 – 326*</td>
</tr>
<tr>
<td>Pupation period</td>
<td>15th April to 16th June</td>
<td>62</td>
<td>13 – 36</td>
</tr>
<tr>
<td>Time from first instar to adult</td>
<td>16th July to 11th May</td>
<td>415</td>
<td>270 – 357*</td>
</tr>
<tr>
<td>Emergence</td>
<td>11th May to 30th June</td>
<td>41</td>
<td>16</td>
</tr>
<tr>
<td>Flight period</td>
<td>11th May to 24th August</td>
<td>105</td>
<td>7 – 105</td>
</tr>
<tr>
<td>Time from emergence to mating</td>
<td>11th May until 27th June</td>
<td>47</td>
<td>11 – 30</td>
</tr>
<tr>
<td>Time from emergence to oviposition</td>
<td>11th May to 10th July</td>
<td>60</td>
<td>14 – 30</td>
</tr>
<tr>
<td>Oviposition</td>
<td>24th June to 24th August</td>
<td>61</td>
<td>5 – 61</td>
</tr>
<tr>
<td>Maximum recorded adult age</td>
<td>31st May to 24th August</td>
<td>86</td>
<td>7 – 86</td>
</tr>
</tbody>
</table>

**Biology**

| Fecundity                                   | 188 maximum eggs per female | 5 – 188 |
| Oviposition stimuli                         | Water soaked Scots pine sawdust (0.5 l) |
| Early instar mortality                      | 24 %**                       |
| Late instar mortality                       | 4 %**                        |

**Rearing/dietary requirements**

| Larval                                      | Minimum 40 ml pine sawdust + 70 ml water per larva |
| Adult                                       | Pollen + nectar (particularly Rosaceae) + dilute honey solution and water |

* Estimated (due to unknown individual first instars), and based on univoltine life cycle
** Based on mortality in 2009 larval growth conditions
between two cages and no further manipulations were made. In total, 11 males and 13 females were recorded mating in the first year (out of a total of 19 males and 19 females).

Oviposition requirements
A number of different techniques were attempted in the small cages to induce oviposition and determine preferences; however, females were not observed ovipositing in artificial rot-holes in either the outdoor or indoor cage environment. Oviposition was triggered only upon sealing gravid females into freezer bags, with wet pine sawdust. Females would begin ovipositing eggs instantly or within 20 minutes of being sealed into the bag.

Females were gravid no sooner than 14 days after first mating. The oviposition period in captivity was between 24 June and 24 August. Each female produced 10-50 eggs per clutch, with up to 188 eggs laid per female (Table 3). In 2009, five females survived to oviposit resulting in more than 463 larvae, and in each of 2010 and 2011, 14 females produced more than 800 larvae.

Rearing captive-bred larvae
Freezer bags of water-soaked pine sawdust and pine hoverfly eggs were sprayed with spring water daily, but otherwise remained un-manipulated for several weeks to avoid harming the eggs and first instars. If larvae had grown sufficiently, i.e. were clearly visible (body length >0.5 mm), the content of the bags was carefully searched, and larvae were counted and transferred into glass microcosms prepared with substrate as described above. Between September and November, a random selection of captive-bred second and third instars (body length >1 cm) were transferred to breeding habitat created at each translocation site (84 in 2009, 51 in 2010, 40 in 2011).

Translocation sites and habitat preparation
Three translocation sites were selected based on four main criteria:
1. Within the species’ historic range, and surveys over a number of years had confirmed its absence at the time of translocation.
2. Of sufficient distance (>5 km) from existing populations that natural colonisation was unlikely.
3. Had sufficient suitable habitat and potential for long-term habitat supplementation.
4. Would receive a long-term (at least 50 years) commitment to protecting, monitoring and supplementing habitat.

A standard approach at each site was used to determine the presence of the hoverfly and the condition of the habitat. Thorough surveys of the area were carried out by means of exhaustive searches, emergence traps over rotting pine stumps, and artificial rot-holes created at least a year in advance, to confirm as far as possible the species’ absence within the area for translocation. Thereafter, habitat creation techniques varied across sites depending on what habitat was available, as detailed below.

Rothiemurchus Estate
This site is 20 km south of Curr Wood on the privately owned, 3,000 ha Rothiemurchus Estate (Fig. 1). The pine hoverfly was first recorded in nearby Aviemore in the late 19th century, and was last recorded in 1942 (Rotheray and MacGowan, 2000). This site was considered suitable for the first translocation attempt due to the large number of Scots pine stumps available for easy habitat creation, and the keen interest of foresters to develop the site for this species as part of their biodiversity action remit.

In 2003, holes were cut in 18 stumps within a 500 m² area using a chainsaw as described above. In 2007, the hoverflies C. rufa and Myathropa florea were found in 12 of 18 rot-holes on Rothiemurchus Estate. Based on empty and live puparia found on site, at least seven C. rufa and 19 M. florea survived to the adult stage in August and September of the same year.

In July 2008, two additional groups of holes in stumps were created, spaced 1 km from each other and the original site, so forming three points of an equilateral triangle. While the design was based on groups of available stumps within the area, this enabled a first estimate of dispersal ability. The two groups consisted of 46 and 30 stumps, giving a total of 94 chainsaw-cut rot-holes. Fifteen Norway spruce stumps (eight and seven at each site) were used in addition to Scots pine to investigate the option of utilising another species of tree, the stumps of which are large and abundant at the site, to create habitat for the pine hoverfly. Rot-holes were created in the same way using a chainsaw.

In September 2009, 84 captive-reared second and third instar larvae were transferred in groups of
three into 28 bored Scots pine stumps at the most northern of the three sites created at Rothiemurchus. This site was chosen because it was the greatest distance from the road, and had the greatest number of bored stumps (46). In May and June 2010, 95 captive-reared adults (50 males and 45 females) were released at the same site (Table 2). In September, 43 first instar larvae were found in 12 stumps, four of which were found in the south-west group 1 km away from the release site, demonstrating that mating and oviposition had successfully occurred.

In June 2011, 30 additional drill-bored holes were created in Scots pine stumps at the most northerly site (Table 1). Between May and June, 48 adults (24 males and 24 females) were released at the same site in Rothiemurchus Estate, and in September three large larvae were found that were considered to be semivoltine i.e. larvae from the previous year developing for two years (Table 2; Rotheray, 2012). Surveys indicated that a total of 37 larvae found at Curr Wood were also semivoltine (Table 2).

Abernethy Forest and Dell Woods

The second translocation site was Abernethy Forest National Nature Reserve, 8 km south of Curr Wood, owned and managed by the RSPB. It extends over 2,800 ha, two thirds of which is native Caledonian forest (Summers et al., 1997) (Fig. 1). The pine hoverfly was first recorded at Loch Garten in Abernethy Forest in 1934, and was last seen in the same area in 1982 (Rotheray and MacGowan, 2000). Since then habitat creation in the area has included setting plastic pots and bored holes has been tried but no pine hoverfly larvae have been found. Stump habitat in Abernethy Forest is limited, so trees were felled to create enough stumps.

The site selected for translocation was a 10 ha plantation where Scots pines range from c. 20 to 50 cm diameter. The site was planted in 1958, and is close to the last observation site for the pine hoverfly at Loch Garten. In August 2010, 100 trees of 28-40 cm diameter were felled. These were distributed evenly across a 10 ha area. They were cut at a minimum height of 28 cm from the ground in order to ensure enough depth for bored holes. The holes were drilled, partially covered using large chain-sawed slabs from the felled tree, and monitored for water retention over several months. Due to a lack of rain, each hole was filled or topped up, using bottled spring water or water from Loch Garten, one month after boring. No relationship was evident between several stump variables (including diameter, circumference, height, and hole diameter) and water retention, which was measured as height of water in the bored hole. In addition to holes in stumps, 10 holes were bored in the side of felled trees to attempt an alternative form of habitat creation, but none of these appeared to retain water.

In 2008, only hoverfly larvae of the genus *Sphegina* were found inhabiting the artificial breeding sites created at Abernethy Forest. In October and November 2010, 87% of bored holes were retaining water two months after felling and hole boring. In September 2010, 51 pine hoverfly larvae were transferred in groups of three into 17 holes. In April 2011, 10 empty puparia and 11 live pupated pine hoverflies were found around the holes. In May and June 2011, 78 adults (30 males and 48 females) were released at Abernethy Forest (Table 2). In September 2011, *Sphegina* spp. larvae (about 30) and three pine hoverfly larvae, considered to be semivoltine, were found in bored holes (Table 2).

Dell Woods, owned by Scottish Natural Heritage (SNH), is 375 ha of native pinewood and is part of Abernethy Forest, 5 km from Curr Wood (Fig. 1). Due to a lack of suitably sized stumps or available Scots pine trees for felling, breeding habitat was created by sinking 16 plastic pots into the earth and filling them with Scots pine chips. They were situated every 2 m along a transect extending from inside the woodland to an exposed area. Surveying here began in 2007 and continued annually until 2010. Four species have been identified inhabiting these plastic pots, but no pine hoverfly larvae or pupae have been found.

Inshriach Forest

The third translocation site was Inshriach Forest, 8 km south of Rothiemurchus Estate, which comprises 3,000 ha of forest and is owned and managed by FCS (Fig. 1). Like Abernethy Forest, Inshriach lacked a sufficient number of large stumps and thus felling was required. A 5 ha Scots pine plantation site was identified where enough suitable trees were available for felling and supplement in the long-term. When investigating habitat creation techniques, it is important to know if suitable habitat can be created as part of normal harvesting rotations. In order to test this, 160 trees were felled comprising two size ranges (20 cm and 30 cm diameter), and two height ranges (60 cm and ‘normal felling height’, roughly 20 cm or as close to the ground as machines allow), duplicated 40 times. Both a petrol-powered drill and chainsaw
(due to logistical and mechanical issues) were used to create holes. Each stump was filled with sawdust created from the boring process, and partially covered with the bored wedge or large pieces left from creating the cavity. Felling and hole-boring were complete by November 2011, and 40 second and third instar larvae in groups of four were transferred into holes retaining water (Table 2). This investigation is continuing.

Conservation genetics and population supplementation

Supplementation of breeding habitat (minimum of 10 newly bored rot-holes per year), and of captive-reared larvae and adults, will continue at each site as necessary until monitoring shows signs that a self-sustaining population exists. To further inform management of these small populations, DNA extracted from pine hoverfly individuals that died in captivity was used to develop microsatellite markers (Rotheray et al., 2011). Genetic variation was measured by comparing the Scottish population with Swedish specimens considered to represent a more outbred population (Rotheray et al., 2012). While the genetic variation was lower in the Scottish population the fitness consequences of this difference are unknown. Therefore further monitoring is necessary in order to detect detrimental effects such as those from inbreeding. To assist these plans, a preliminary investigation into non-invasive techniques for extracting DNA was carried out (Rotheray, 2012). Sufficient DNA for microsatellite amplification was extracted not only from small pieces of adult tissue such as single, terminal tarsal segments and wing tips, but also from sections of year-old empty puparia (Rotheray, 2012).

Unfortunately, 2011 appeared to have been a very poor year for the pine hoverfly at all sites, including the main natural wild population at Curr Wood. No new larvae were found at any site in 2011, the surviving populations consisting of larvae that were developing over two years. This suggests a failure of adult breeding at all sites, perhaps due to cold and wet weather during the adult breeding season. Large population fluctuations due to stochastic events are not uncommon in insects. The pine hoverfly may have a ‘bet-hedging’ strategy in order to cope during these adverse periods, involving a number of larvae developing over two years regardless of growth conditions. However, with the current precariously low population size, periods when larval habitat is very restricted could drive the species to extinction. Efforts are currently underway to apply the techniques developed under the SAF project to continue captive breeding of the pine hoverfly at Edinburgh Zoo (see below).

Publicity

- During the SAF project, seven oral presentations were given to academics and interested parties or enthusiasts on the conservation management of the pine hoverfly.
- In 2009, the translocation of the pine hoverfly to Rothiemurchus Estate was publicised in several local and national newspapers, and on several websites including the BBC.
- BBC Radio Scotland’s Out of Doors programme featured the project during the translocation at RSPB Abernethy in 2010.
- BBC Autumnwatch Live filmed a short piece recording the third translocation of pine hoverfly larvae into Inshriach Forest in 2011. This was made available through a link on the presenter Liz Bonnin’s blog website.

Lessons Learnt, Further Work and Future Recommendations

1. The main difficulty in captive breeding and translocation projects for invertebrates is often that there are few analogous studies and very little background information, unlike the case for most vertebrates. Well-managed breeding programmes as properly integrated
components of wider efforts have good conservation potential, and should continue in order to supplement translocation efforts and preserve the species.

2. Having an effective means to measure abundance of any endangered species is essential to monitor population trajectories and the effectiveness of management actions. The most cost-effective approach for the pine hoverfly is to focus survey work on the larval stage, as it occupies a discrete, easily monitored habitat, sampling is not invasive, and we now know enough about the life cycle to design suitable protocols. Optimal detection time is late summer (August to September).

3. We can also monitor the genetic health of populations by extracting DNA from empty puparia. Acquiring DNA in this way will also facilitate monitoring of captive-bred populations, where non-invasive sampling methods are required to prevent the inadvertent mortality of rare captive specimens.

4. Intraspecific larval growth experiments demonstrated that competition for resources can occur in artificial rot holes, therefore future translocations should ensure that the smallest possible number of pine hoverfly larvae is introduced into each rot hole. While interspecific competition in a rot-hole is not likely to affect the recovery of the pine hoverfly, further experimentation may identify whether there are competition effects between species for resources that may inhibit growth and larval survival.

5. The success of re-establishment depends on on-going management at translocation sites and at Curr Wood, where expansion and supplementation of the breeding habitat is imperative. This requires long-term cooperation of landowners and managers to implement informed, conservation-based practices. Management for the pine hoverfly is inexpensive, and can probably fall in line with normal harvesting rotations. Investigations should continue at Inshriach Forest.

6. Forestry in the UK now includes retaining deadwood, including stumps, as part of management guidance and good practice, however widespread understanding and appreciation of the biodiversity importance of deadwood is needed (Forest Enterprise, 2002).

7. Fundamental knowledge of the ecology and natural history of the pine hoverfly, and clarification of some of the practical approaches that will be required in its conservation, have only been achieved through the full-time employment of a project manager under SAF. This study is an example of what can be achieved in four years of focused research, in cooperation with foresters, landowners and managers, to re-establish an endangered insect.

Key Management Messages

• To create habitat suitable for the pine hoverfly’s larval stage, rot-holes should be bored into Scots pine stumps of at least 30 cm diameter. Where possible, these should be filled with wood chips or sawdust, and protected from desiccation by partially covering with wood or bark.

• Adult pine hoverflies feed on a wide range of plants associated with Scots pine woodland. In addition to retaining or planting flowering trees such as rowan and bird cherry, opening the canopy and creating or keeping woodland-edge habitat should naturally encourage such flora.

• Conservation management on the landscape scale should consider that the pine hoverfly can disperse 1 km.

• To establish presence and monitor populations over time, survey work should focus on the larval stage of the pine hoverfly. The optimal detection time is late summer (August to September).
New and ongoing work since SAF ended

Population levels of the hoverfly continue to give concern, and increased effort is being put into habitat creation to supplement the older artificial holes at the key sites. The captive breeding population at Stirling University was unfortunately lost and now efforts are underway to establish a new population. The Royal Zoological Society of Scotland (RZSS) now has a bespoke rearing facility in place at Edinburgh Zoo. Twenty-three pine hoverfly larvae have been obtained from Finland and these are being used by Zoo staff to gain experience in breeding this species with the potential for these being used to supplement the Scottish populations. This can only happen if the strict criteria set out by the National Species Reintroduction Forum are met. Hopefully Scottish material will be available for this project in 2016.

Other continuing and new areas of work include:

- Management action, mainly focused on the Curr Wood and Abernethy sites, with new artificial rot holes being created – 43 to date at Curr Wood and a continuing programme of c. 10 per year at Abernethy.
- Replenishment of existing holes at Curr Wood with new wood chips, and general maintenance.
- Annual monitoring at existing sites.
- Artificial holes have been cut at a new site, Loch Vaa, by Seafield Estate. These will continue to be monitored and ‘seeded’ with larvae when these become available.

Further Information


Two additional publications written about the project include:


References


The SAF Partners

- The Malloch Society
- The Royal Society for the Protection of Birds
- Forestry Commission Scotland

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Slender Scotch Burnet Moth

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Summary

• The day-flying slender scotch burnet moth (Zygaena loti subspecies scotica) is currently only known in the UK from five populations on the islands of Mull, Ulva and Gometra in western Scotland. Furthermore, the subspecies scotica is presumed to be endemic to Scotland, not occurring anywhere else in the world.

• The moth occupies species-rich grassland areas close to the coast, typically on sunny, south-facing undercliffs. Most sites are maintained in suitable condition by light, seasonal grazing hence the fortunes of the moth are closely linked to traditional agriculture.

• The main aim of the project therefore was to deliver appropriate management advice to benefit the moth. A steering group was formed comprising Scottish Natural Heritage (SNH), Forestry Commission Scotland (FCS) and Butterfly Conservation Scotland (BCS), who jointly funded a Project Officer to carry this out. The role of the Project Officer also included action for the two other Lepidoptera listed in the Species Action Framework (SAF), pearl-bordered fritillary (Boloria euphrosyne) and marsh fritillary (Euphydryas aurinia), as well as the chequered skipper butterfly (Carterocephalus palaemon), an FCS priority species.

• The project objectives were achieved by working in close partnership with SAC Consulting (Scottish Agricultural College, now part of Scotland’s Rural College, SRUC) to provide site-specific management advice on the moth to their clients, to help them gain entry into the Scotland Rural Development Programme (SRDP) Rural Priorities (RP) scheme.

• During the course of the project all eight ownerships where slender scotch burnet moth had been recorded were visited. Four of these are now being managed specifically for the moth under SRDP, whilst management was also undertaken on two others using SAF project funding. The remaining two are not ideally suited to SRDP although fortunately there are currently no pressing management issues.

• During the course of the project one new population was discovered and the moth was also found to be far more widespread at two of its major populations. A further nine sites adjacent to, or close to, known colonies that have suitable habitat are also now being managed specifically for slender scotch burnet under SRDP, although the moth has not yet been recorded from these sites.

• The success of this project is primarily due to the co-operation and goodwill of the site landowners/managers and their agents and the willingness to work together.

Introduction

Fig 1. Slender scotch burnet moth.
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Species background

Due to its great rarity, very limited distribution and declining population, the slender scotch burnet moth was listed as a UK Biodiversity Action Plan (UK BAP) Priority species. It is also listed in the Red Data Book as RDB3-Rare and included on the Scottish Biodiversity List. The moth is currently only known in the UK from five populations on the islands of Mull, Ulva and Gometra in western Scotland (Fig. 2) occurring in seven different, but adjacent, 10-km squares. Prior to 1945, the moth was also present on the Scottish mainland across the Sound of Mull on Morvern, where it is now believed to be extinct. The subspecies scotica is As with other threatened Lepidoptera the declining fortunes of this species are believed to be the result of habitat loss as well as inappropriate habitat management. This is coupled with the need for sufficient area and networks of habitat for the moth to form meta-populations, where losses and
even extinctions at one colony can be balanced by gains and recolonisation from neighbouring colonies.

The slender scotch burnet moth inhabits low undercliffs and grassy banks at or near to the coast.

General ecology

The slender scotch burnet moth inhabits low undercliffs and grassy banks at or near to the coast.

It is usually restricted to slopes with a sunny, south or south-west facing aspect and underlying basalt rock where its larval foodplant, bird’s-foot trefoil (*Lotus corniculatus*), grows in an open sward. Both the moth and the larval foodplant favour an early stage of vegetation succession, with short vegetation and pockets of bare ground. This provides a warm micro-climate that is essential for both the larvae and the adults.

The adults, which have a wingspan of 25-35mm, are most easily observed and monitored in warm, sunny weather between mid-June and the end of July. In poor weather they can often be found perching on stems, or taking shelter lower down amongst the vegetation. Adult males spend a proportion of their time flying around seeking females who tend to perch, nectaring mainly on the larval foodplant, but also on other flowers such as milkwort (*Polygala* spp.), common cat’s-ear (*Hypochaeris radicata*) and wild thyme (*Thymus polytrichus*). The eggs are laid in a single-layered batch in late June to early July. Overwintering takes place as larvae and they attain full growth around late May of the following year. The larvae (Fig. 4) bask on bare soil, rocks and moss cushions around the larval foodplant in good weather.

The moth’s ecology and management requirements are fairly well understood and therefore suitable management practices can be applied to enhance its habitat and populations. Slender scotch burnet moth was therefore an ideal candidate for SAF status since it is a threatened species whose ecology is well known, only surviving in the UK at a handful of small sites, all in Scotland. However, conservation action for slender scotch burnet moth has to be done at a landscape scale and requires positive engagement with landowners and land managers. This will also be beneficial to other wild-life that shares its habitat.
A proportion of the larvae re-enter diapause after emerging from hibernation. This is a beneficial strategy and reduces the risks of in-breeding as well as acting as an insurance policy against poor Scottish summers. It is not known how many times they can repeat this but it may explain some of the large annual fluctuations that can occur in adult populations. The larvae pupate in late May to early June in a cocoon that is spun on the ground, concealed amongst grass and other vegetation.

**Habitat management**

Slender scotch burnet sites are best managed as species-rich grassland with a spring/summer grazing break to maintain and enhance floristic diversity. Grazing by sheep and cattle is preferred as sheep produce a short sward which creates the all-important warmer micro-climate favoured by both adults and larvae, whilst the heavier cattle allow small areas of bare ground to develop in the sward through light poaching, which benefits both basking larvae and the establishment of bird’s-foot trefoil. Some of the more remote sites are probably maintained in suitable condition by deer and wild goats. In the absence of sufficient grazing, bracken (*Pteridium aquilinum*) and scrub encroachment can be very detrimental. On steeper terrain and undercliffs, the natural instability of the cliffs helps maintain habitat condition through landslips and rockfalls. This creates areas of bare ground that in time are slowly colonised by bird’s-foot trefoil.

At one slender scotch burnet site non-native cotoneaster (*Cotoneaster sp.*) is steadily encroaching into the species-rich grassland reducing the area of suitable habitat for the moth.

**Action before the Species Action Framework**

Prior to SAF, work on slender scotch burnet moth was overseen by the Burnet Study Group (BSG). However, BCS had also undertaken various activities and already had good contact with most of the colony owners, as well as raising awareness of the moth on the island through hosting events and writing articles in the local press. Local volunteers had been recruited to undertake surveys, recording and monitoring of the moth. On Ardmeanach peninsula work on slender scotch burnet was led by the National Trust for Scotland (NTS), whose Burg property holds the largest and most important population in the UK. This is reflected in the site being part of the Ardmeanach SSSI for which slender scotch burnet moth is a notified feature.

A colour leaflet *Learn About Scotland’s Burnet and Forester Moths* had also been produced aimed at both recorders and land managers. It provides useful information on slender scotch burnet moth - its life-cycle, identification, ecology and habitat management requirements.

**Aims**

**Aims and objectives for 2007-2012**

The overall aim of the project was to influence land management to enhance the habitat for slender scotch burnet moth, rather than to undertake research, survey and/or monitoring. The key objectives were to:

- Ensure that all known populations are in favourable long-term management, principally under SRDP Rural Priorities.
- Maintain populations at existing sites and increase the area of slender scotch burnet moth habitat.
- Raise awareness and appreciation of slender scotch burnet moth and its requirements.
Management Action

Summary of the main actions carried out

The objectives were addressed through the following:

• **Specialist adviser** – a Project Officer was employed to provide specialist advice.

• **Bringing land into suitable management under SRDP Rural Priorities** – the Project Officer assisted landowners/managers, through their agents, to gain entry into Rural Priorities and ensure appropriate management at suitable sites.

• **Specific management activities** – activities ineligible or impractical to fund under SRDP were undertaken by using contractors and/or volunteers. This included fencing and control of cotoneaster, scrub and bracken.

• **Awareness raising** – the BCS colour leaflet Learn About Scotland’s Burnet and Forester Moths was updated and reprinted and the project promoted via various talks and press articles.

Steering Group and Project Officer

A steering group was formed in 2008 comprising SNH, FCS and BCS. This group jointly funded a Project Officer, employed by BCS, to encourage appropriate action on the ground for slender scotch burnet moth. NTS also joined the steering group because of the important colonies they manage on their property at Burg. The Project Officer’s role included action for the two other SAF-listed Lepidoptera, marsh fritillary and pearl-bordered fritillary, and for chequered skipper, which is listed as a priority species in the Scottish Forestry Strategy. The group met once or twice a year to review the work undertaken and to help steer future work on all four species. The work on slender scotch burnet moth was also reviewed by the BSG at their annual meeting.

Initial plans and success through partnership

The very restricted range of the moth, along with previous contact by BCS with most of the site owners, meant that it was a comparatively easy process to plan and undertake visits to identify management issues. Fortunately this coincided with the launch of the RP scheme under SRDP. The approach used to deliver successful RP applications for marsh fritillary, by working in partnership with SAC Consulting and other key agents, was therefore adopted for slender scotch burnet moth. This was made easier as SAC Consulting are the main agents for landowners seeking entry into RP on Mull. The Project Officer therefore took on the role of specialist adviser, and was directed by SAC Consulting to owners on Mull interested in gaining entry into RP. This required site visits to see if there was suitable or potential habitat for slender scotch burnet moth on their land and to work together on an RP application. Successful applicants receive an annual payment rate per hectare of land being managed and this lasts for five years.

Results

During the course of the project all eight ownerships where slender scotch burnet moth had been recorded since 2000 were visited, and all are now aware of the moth and its habitat requirements. Four of these are now being managed specifically for slender scotch burnet moth under SRDP, whilst management has also been undertaken on a further two using SAF project funding. The remaining two are not ideally suited to being managed under SRDP but currently there are no management issues at these sites.

During the course of the SAF project one new population was discovered, at Glengorm, bringing the total to five populations: Glengorm, Langamull, Kilninian, Ulva and Ardmeanach. The moth was also recorded on Gometra for the first time, extending the range of the Ulva population. Additionally slender scotch burnet moth was found to be far more widespread at Ardmeanach, Langamull and on Ulva. These new finds are clearly shown by the green dots in Fig. 5 below.
Fig 5. Location of recently discovered slender scotch burnet moth colonies. Post-2000 (green dots), 1980-1999 (orange dots). The orange dots are overlain on top of the green dots, therefore, any green dots showing are new post-2000 sites.

A further nine sites adjacent or close to known colonies that have suitable habitat are now also being managed specifically for slender scotch burnet moth under SRDP, although the moth has not yet been recorded from these sites. A further 28 sites on Mull were visited, primarily for marsh fritillary assessments, but no suitable or potential habitat for slender scotch burnet moth was found. The location of all sites under each category, along with the distribution of the moth, is shown in Fig. 6.

Fig 6. Location of sites where management advice has been given to benefit slender scotch burnet moth. The map shows distribution of moths post-1980 (orange dots), extant sites where management has been undertaken (yellow triangles), sites being managed for the moth with suitable habitat but where the moth has not been recorded (blue stars), and all other sites in the range of the moth where management advice has been delivered but no suitable habitat found (purple squares).

Site summaries

This section summarises the management that has been undertaken at all sites to benefit slender scotch burnet moth during the project. Most sites were managed under the RP Management of species-rich grassland option under RP with a bespoke grazing plan that included either a summer grazing break, or greatly reduced stocking rates over the summer, to enhance floristic diversity. In some instances, depending on the surrounding habitat, the Management of coastal heath or Management of habitat mosaics option was used.
The sites are listed below from north to south. Those marked with an asterisk* are sites where slender scotch burnet moth is known to be present.

**Glengorm**

The population on Glengorm Estate was discovered during an SRDP site visit in 2010 to assess the habitat on the estate for marsh fritillary. Slender scotch burnet moth was found at five locations in two different management units, at least 0.5 km apart. Both fields are now being managed specifically for the moth under RP. However, in 2011 and 2012 further survey work found the moth to be more widespread. The owner is aware of these locations and hopefully they will be managed sympathetically in the meantime.

**Penmore**

Penmore Farm lies around 1 km between the two known populations at Glengorm and Langamull in the north of Mull and can therefore act as an ideal stepping stone to improve the links between these two areas. However, despite the presence of suitable habitat slender scotch burnet moth has not been recorded from the site, but it is now being managed under RP for the moth.

**Langamull**

This population was discovered in 2006 and comprises two sites, Langamull House and Port Langamull. They are less than 1 km apart but under different ownerships.

The Langamull House colony is not eligible for SRDP funding as it is not on actively managed agricultural land. However, with the owner’s permission and SAF project funding, a contractor controlled a small area of bracken and also repaired the perimeter fence to make the area stockproof. It was hoped that a local grazer would then provide stock to lightly graze the two small fields to enhance the habitat, but this has not been achieved at the time of writing.

Port Langamull lies within a large coastal area that is being extensively grazed which will benefit the moth, but most of this land is not categorised as inbye and therefore payment rates under SRDP are too low to entice the owner to enter the land into the scheme. However, one area has been enclosed and is being grazed seasonally to benefit the moth whilst two adjacent sites are also being managed for the moth under RP.

**Kilninian**

The slender scotch burnet moth colony at Kilninian is threatened due to the encroachment of a non-native invasive species of cotoneaster on the steep, species-rich grassland undercliffs. Control of cotoneaster, unlike other non-native species such as *Rhododendron ponticum* or Japanese knotweed (*Fallopia japonica*), is not eligible under SRDP funding. As a result its control has been undertaken by a combination of contractors and local volunteers using SAF project funding (Fig. 7).

The steep uneven terrain combined with the remoteness of the site meant that site-specific techniques had to be developed if the control was to be successful. Different techniques were trialled, including the use of power tools, and blanket spraying with glyphosate of areas completely dominated by cotoneaster. However, the most practical site-specific solution found was cutting back the cotoneaster using hand tools (loppers and secateurs) and then treating the cut stumps with a 15% glyphosate solution. A coloured dye was added to the chemical to help identify treated cut stems. Specialist rope-access contractors were also brought in to control plants growing on the crags and steep inaccessible slopes (Fig. 8). The priority was always to ensure that cleared areas remain cotoneaster-free and these were regularly checked for missed and re-seeding plants before new areas were tackled. Around 700 m of undercliff has been successfully cleared.
Excitingly around eight slender scotch burnet moths were recorded from the site in 2012, the first time since 2009 and the highest count this century! This work has also improved stock access to the undercliffs which will help maintain the site in suitable condition.

In addition four adjacent units have also successfully entered land into RP specifically to enhance suitable/potential habitat for slender scotch burnet moth. In some cases this included applying site-specific grazing plans whilst in others the management focused on bracken control.

Ulva and Gometra*

During the course of the SAF project the status of the moth on Ulva and Gometra has greatly improved. Prior to 2009 there were only two colonies of slender scotch burnet moth on Ulva. However, targeted surveys by the owner and volunteers has improved our knowledge of the moth’s distribution, showing it to be far more widespread with a series of almost connected colonies, a meta-population, along the entire south-facing side of the island. The surveys also produced the first confirmed records from Gometra. Ulva now has a successful RP scheme that includes a site-specific grazing plan to enhance the inbye ground colonies, and bracken control and increased grazing on the hill ground colonies. In addition, liaison over a woodland creation/expansion scheme ensured that it did not impact on the island’s important moth colonies. The owner of Gometra is very sympathetic to the presence of the moth but the island is not suited to SRDP, not having any stock or active inbye ground. Also the site does not seem to be currently under threat and is probably being kept in suitable condition through deer grazing.

Ardmeanach*

The Ardmeanach peninsula holds the most significant population of slender scotch burnet moth in the UK. The component colonies are under two ownerships, with those in the west being on the NTS property at Burg. Both sites have been successfully entered into RP with management targeted at enhancing the habitat for the moth through bracken control and grazing. Scrub control has enhanced the habitat at two small adjacent colonies in Slochd Wood and at the Scobull Triangle by using volunteers, particularly participants on NTS Thistle Camps. The volunteers on this scheme have also greatly increased the surveying and monitoring activities on the peninsula and found the moth to be more widespread with the discovery of a number of new colonies.

Ross of Mull

Suitable habitat for slender scotch burnet moth was found on two sites near Ardalanish on the Ross of Mull, although the moth has never been recorded from the Ross. Both sites are now being managed under SRDP to enhance this habitat in the hope that the moth may colonise the site.

Morvern

The moth was last recorded from Morvern in 1945 adjacent to the Sound of Mull. Site advisory visits to two landowners where the moth may have formerly occurred found suitable habitat on Ardtornish Estate on the steep undercliffs to the east of Ardtornish Point. This land, however, is in a woodland scheme so is currently ineligible for SRDP funding.
Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

The success of the project is almost solely due to working in partnership with agents from SAC Consulting and the resulting co-operation and enthusiasm of the landowners. This resulted in the Project Officer acting as a specialist adviser to enhance and encourage RP applications specifically targeted at slender scotch burnet moth. This followed the blueprint developed for the SAF marsh fritillary project and so the lessons outlined in the marsh fritillary chapter of this handbook also apply to this work on slender scotch burnet moth. In particular the chapter sections headed Problems and solutions, Lessons learnt, Specialist adviser, Partnership working and SRDP are all very relevant to the moth.

Future recommendations

Despite the success of this project further work is required, particularly at those sites that were ineligible for management under RP. Our recommendations include:

- Continue cotoneaster control at Kilninian.
- Bring the remaining part of the Port Langamull site into suitable management.
- Establish suitable grazing at Langamull House.
- Ensure colonies on Ulva and Gometra are sufficiently grazed.
- Encourage suitable management at Slochd Wood and the Scobull Triangle.
- Encourage surveys at sites being managed for the moth under RP but where there are currently no records, particularly at Penmore and the sites on the Ross of Mull, and at other suitable sites. Also encourage surveys on the mainland on Morvern.
- Establish base-line monitoring of vegetation and adults at sites being managed under RP so that the effects of management can be quantified. These results will help to improve the quality of future advice given.
- Identify where there is suitable/potential habitat on other sites on Mull, and across the Sound of Mull on Morvern, and try to bring them under suitable management through RP. Priority should be given to sites that would improve connectivity within or between the current populations.
- Maintain contact with all owners in order to sustain the current good relations and their favourable stance towards the moth.

New and ongoing work since SAF ended

Work on slender scotch burnet moth post-SAF has continued, as before, under the auspices of the BSG implemented by its members, particularly BCS, SNH and NTS.

Survey and monitoring

Monitoring of the adult moth has continued at most of the main colonies mainly through BCS, NTS and their volunteers. Moth numbers have fluctuated but were probably slightly up in 2013. At both Glengorm and Langamull the moth has been found in further new areas, but no other new colonies have been discovered.

Glengorm Estate appointed a ranger in 2013, part of whose role will be to monitor the effects of the prescribed management on both the moth and the vegetation.

Management

Management as prescribed under RP, mainly seasonal grazing, has been applied at all sites with successful SRDP applications (i.e. the yellow triangles in Fig. 6). This required erection of fencing around the inbye ground at the Burg before controlled grazing could be done. A small herd of Hebridean sheep has been put onto the hill ground on Ulva to prevent the vegetation becoming too rank. Bracken spraying to prevent further encroachment onto suitable moth habitat and improve the grazing for livestock has also been undertaken on the Burg and adjacent Kilfinichen Estate. In addition the grazing plan at the Burg has been reviewed to give the grazier a clearer steer on what is required in terms of number of stock and exact timings.

Additional cotoneaster has been cleared at the Kilninian site by contractors from Coille Alba and BCS volunteers. Also a free, three-day pesticide course, organised by Coille Alba and BCS, was held on Mull in the hope of recruiting suitably trained local contractors to continue the cotoneaster clearance. This should reduce the cost of
control through minimising travel and accommodation expenditure, as well as providing a more flexible workforce that can take better advantage of suitable weather. Further clearance is planned using attendees alongside volunteers in 2014.

Research

In 2013 a PhD student from Durham University undertook fieldwork on Ulva to look at the effect of grazing on vegetation structure and composition in relation to slender scotch burnet moth and marsh fritillary habitat. His initial fieldwork has focused on deer behaviour but he plans to collect burnet moth data from 2014, as his exclusion plots will have been in place for a year by then. Dr Joe Burman from Canterbury Christ Church University specialises in synthesising moth pheromones. In 2013 he developed lures for New Forest burnet moth (Zygaena viciae) and successfully tested them in the field. He is now planning to develop lures for slender scotch burnet. These could prove very useful in helping to discover new colonies, and possibly as a monitoring technique.

Burnet Conference

BCS, BSG and SNH jointly organised the XIV International Conference on the Zygaenidae, on Mull in September 2014. Part of the conference focused on Scottish burnet moths including slender scotch burnet moth and included field trips to some of the sites where work has been carried out under SAF. This provided a very useful opportunity to highlight this work to an international audience.

Concerns

Since 2011 it has become increasingly difficult for applicants to gain entry into RP. Subsequently there have been no new applications to manage land specifically for slender scotch burnet moth since 2012. In addition the new SRDP scheme will probably not be open to applicants until 2015. It is currently unclear whether slender scotch burnet moth will be given sufficient priority to encourage owners to consider entering their land into RP to benefit the moth, or if the new payment rates will make applications economically viable. This uncertainty and the short-term nature of the scheme are not helpful and discourage many potential applicants.

Key Management Messages

- Slender scotch burnet moth sites should be managed at a landscape scale.
- Advice should be site-specific and delivered by a specialist adviser.
- Its fortunes are closely linked to traditional agriculture and High Nature Value (HNV) farming systems.
- The moth requires a warm micro-climate so is usually restricted to sunny undercliffs and slopes on basalt rock where its larval foodplant, bird’s-foot trefoil, grows in an open sward.
- The adult moths benefit from areas of species-rich grassland/heathland to nectar in.
- Sites are best maintained by light grazing with sheep and cattle.
- A spring/summer grazing break helps maintain and enhance floristic diversity.
- On steeper terrain grazing is less crucial as landslips and rockfalls help new areas of habitat develop.
- In the absence of sufficient grazing, bracken and scrub encroachment can be detrimental.
- One site is threatened by invasion of non-native cotoneaster. This is best controlled by using hand-tools and treating the cut stumps with herbicide.
- The project’s success was due to the close working partnership between agents, land managers/owners, case officers and the Project Officer.
There is also an issue about getting moth habitat into SRDP because of the tight restriction of many of the grazing options solely to inbye land. This is further compounded by the lack of a clear definition for inbye and coastal heath. For this reason NTS has now had to withdraw from the scheme, though fortunately the two capital elements, fencing and bracken spraying, have been completed and are not affected.

This is a significant issue for many land managers, which needs to be resolved by increasing payment rates for grazing management on non-inbye land, thereby encouraging owners to enter and retain such important land in RP to benefit the moth and other key species.

In 2013 the Langamull House site went on the market. Like the majority of slender scotch burnet moth sites, it is not designated or protected in any way. The aim will therefore be to engage with the new owners and discuss how the site can be maintained in a way that benefits the moth.

**Further Information**

- [http://www.snh.gov.uk/speciesactionframework](http://www.snh.gov.uk/speciesactionframework) – SAF web page that provides links to slender scotch burnet moth information.

**References**


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Without this collaboration and support the future of slender scotch burnet moth would be very bleak.

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The SAF Partners

- Scottish Natural Heritage
- Butterfly Conservation Scotland
- Forestry Commission Scotland
- Scottish Agricultural College
- National Trust for Scotland

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to [www.snh.gov.uk/speciesactionframework](http://www.snh.gov.uk/speciesactionframework)

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Bird’s Nest Stonewort

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Summary

- Two lochs in North Uist, Loch an Duin and Loch an t-Sruith Mhoir, were subject to a detailed survey for bird’s nest stonewort (Tolypella nidifica) in 2009, in respect of distribution, abundance and ecological context.
- Both lochs were found to be subject to few adverse pressures, and prospects for bird’s nest stonewort and other rare lagoon species were regarded as good. The only long-term threat to rare lagoon organisms in these lochs is judged to be climate change, especially rise in relative sea level.
- Within a relatively wide salinity range, the main environmental demands of bird’s nest stonewort appear to be a sandy substrate and bioturbation of this substrate.
- Applying the knowledge gained from the 2009 surveys to lochs formerly holding the species suggests that any attempts at re-establishment are likely to fail because of changes in the status of the lochs involved.

Introduction

Bird’s nest stonewort (Tolypella nidifica) is a brownish-green charophyte (a type of alga) which grows on sandy substrates in brackish waters (Fig. 1). It is listed in the stonewort Red Data Book with ‘Indeterminate’ status (Stewart and Church, 1992) but was listed as ‘Endangered’ in Britain in the subsequent review (Stewart, 2004). It is now confined to two sites in the UK, both saline lagoons in North Uist, having apparently disappeared from two sites in Orkney and two in England. Thus it qualified for consideration in the Species Action Framework (SAF) (Scottish Natural Heritage, 2007) as a species that has demonstrated a significant decline.

Fig 1. Bird’s-nest stonewort with lagoon cockle (Cerastoderma glaucum) and filamentous algae, Loch an Duin, North Uist.
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Bird’s nest stonewort is now found only in Loch an Duin (Ordnance Survey grid reference NF 894743) and Loch an t-Sruith Mhoir (NF 904691), where it was reported by Martin (2001) (Fig. 2). Both these saline lagoons are within the Loch nam Madadh Special Area of Conservation, and both have a particularly wide range of specialist lagoon species, having all the Scottish lagoon specialists apart from the crustacean Lekanesphaera hookeri, which is widespread in Uist lagoons but has not yet been recorded from these sites (Howson et al., 2014; S. Angus, unpublished).

Fig 2. Southern basin of Loch an Duin, looking northwards.
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Bird’s nest stonewort was reported from Loch of Boardhouse in Orkney (HY 271258) in 1923, but has never been relocated, despite several detailed surveys, including one that surveyed vegetation at 195 points (Murphy and Wallace, 2004). Though exposed to sea spray, this loch is sufficiently fresh to serve as the main water supply for Mainland
Orkney. It has a surface at 15 m AOD (Above Ordnance Datum) and is relatively shallow (maximum depth 3.2 m), and there is nothing to suggest that it has ever been connected to the sea in recent times. The bed is dominated by filamentous algae and pondweeds, but supports fragile stonewort *Chara globularis* var. *virgata* and rough stonewort *C. aspera* var. *asera* with the latter the fourth most abundant plant (Murphy and Wallace, 2004).

The other Scottish record is from the Loch of Stenness, also in Orkney (HY 283128), which is the largest saline lagoon in the UK. Despite an extensive species list, it contains very few lagoon specialists; bird’s nest stonewort was last recorded in 1994, and the bearded stonewort *C. canescens* has not been seen since 1926 (International Centre for Island Technology, 2004). The latter is now confined in the UK to some pools on Baile Sear in North Uist and an old brickworks in Peterborough (Stewart and Church, 1992). The Loch of Stenness is reportedly becoming more saline, and has also been affected by the installation of Rap-valves in the Brig o’Brodgar in 1968 (renewed in 1993) that significantly change water circulation (Angus, 2013).

Both Loch an Duin and Loch an t-Sruith Mhoir are largely unaffected by human influence apart from causeways and their associated culverts. Loch an t-Sruith Mhoir has a single basin and is connected to the sea at its eastern end by a short, angled channel. The loch has a depth of 3.7 m over much of its extent, with a maximum depth of 6.7 m (Murray and Pullar, 1910). Loch an Duin has a complex outline and five basins, and is around 2 m deep over much of its extent, but has a ‘hole’ 10.7 m deep in its north-western basin; the two south-eastern basins are connected to the sea by short, culverted channels (Murray and Pullar, 1910) (Fig. 3).

Loch an Duin and Loch an t-Sruith Mhoir are listed by Stewart (2004) as ‘Important stonewort areas’ on the grounds that they meet national criteria in terms of containing a population of a threatened species and containing a threatened species plus two other species of stonewort. They also form sub-sites of Important Stonewort Area 108 (Lochmaddy area, North Uist) which is a site complex considered to be of European Importance.

### Aims

The original aim of the SAF project for bird’s nest stonewort (SNH, 2007) was to work towards two existing UK Biodiversity Action Plan objectives, to:

- Maintain and enhance existing populations and restore populations at former sites where appropriate.
- Maintain the range and number of sites including, where appropriate, through introduction to adjacent localities, where existing localities become unsuitable.

The actions listed were to:

1. Establish the status and extent of the species at its current and recent sites.
2. Ensure that appropriate management is in place at existing localities.
3. Produce a management advice note on the species.
4. Assess the current state of former sites and ascertain the conditions required for reinstatement at former sites.
5. Develop cultivation/propagation techniques for the species.
6. Carry out reinstatement at previous sites, if conditions found to be suitable.

### Action Under SAF

Of the six actions listed above, the first priority was clearly to determine the current status and distribution of bird’s nest stonewort in its two remaining sites (Action 1). Within this study, contractors were also required to report on management (Action 2) and on potential for reinstatement at former sites (Action 4). The other three actions were entirely dependent on the results of this work.
Survey of Loch an Duin and Loch an t-Sruith Mhoir

The survey was conducted in August 2009 by Sue Scott and Angela Darwell, working for Nick Stewart, with the project managed by Stewart Angus. All were present during at least part of the survey, with Scott and Darwell throughout (Scott et al., in prep.).

Prior to this survey, there was no detailed information on the distribution of bird’s nest stonewort within any loch. The contractors were also asked to report on the distribution of other stoneworts and lagoon organisms, giving additional detail on those associated with bird’s nest stonewort. A range of environmental attributes (temperature, salinity, depth, oxygen and, in low salinities, pH) was also measured.

Both lochs were strongly stratified, with a halocline (a steep, vertical salinity gradient) at around 1 m, becoming slightly shallower with increasing distance from the exchange with the sea. The denser, more saline water had a layer of lighter, less saline water on top.

A network of paired data-loggers was established in Loch an t-Sruith Mhoir in winter 2011-12 (Nov-May) to measure salinity, temperature and pH at depths within any upper or lower layers that might become established. Initial analysis of the logger data from the centre of the loch suggests that any haloclines were short-lived in November (possibly originating from periods of heavy rain) but the halocline disappeared completely in December, re-establishing only briefly in February before building up to a more stable summer situation in April. As would be expected from variations in rainfall, the lower level was more stable than the upper level over the winter (S Angus, unpublished).

In Loch an t-Sruith Mhoir, bird’s nest stonewort was found at scattered locations in the middle and western sections of the loch (Fig. 4). The substrate was usually sandy, and water depths were usually less than 0.8 m, with only four populations below 1.5 m. Salinity of bird’s nest stonewort sites ranged from 17.85 to 19.99‰ (parts per thousand). The commonest associates were fennel-leaved pondweed (Potamogeton pectinatus), tasselweed (Ruppia sp.), fucoid seaweeds, foxtail stonewort (Lamprothamnium papulosum) and filamentous

Fig 4. Distribution of Bird’s nest stonewort in Loch an t-Sruith Mhoir, North Uist.
algae. The rare foxtail stonewort occurred throughout the loch, while rough stonewort (a common species) and the rare Baltic stonewort (*Chara baltica*) were confined to a small inlet at the extreme western end of the loch (Scott *et al.*, in prep.).

Bird’s nest stonewort grew in more extensive beds in Loch an Duin, mainly on sandy substrates in very shallow water, but occasionally on flocculent mud. It was widely distributed northwards to the inlet leading to the two northernmost basins, although it was absent from the basins themselves (Fig. 5). There were four populations living below 1.5 m, all associated with shallower populations, as in Loch an t-Sruith Mhoir. Salinity of bird’s nest stonewort sites ranged from 6.36 to 18.5%. The main associates were fennel-leaved pondweed and tasselweed. Rough stonewort was common in the north of the system, including the basins from which bird’s nest stonewort was absent, while Baltic stonewort was widely distributed, absent only from the large southern section. Foxtail stonewort occurred throughout the system (Scott *et al.*, in prep.).

Water samples from both lochs were analysed by the Scottish Environment Protection Agency (SEPA) for levels of orthophosphate, nitrate, nitrite, total oxidised nitrogen, dissolved organic nitrogen, ammonia, non-ionised ammonia and silicate. Levels of all these were very low except for two samples taken from inflows to Loch an t-Sruith Mhoir; samples from the loch nearby confirmed that elevated levels were highly localised. Generally, levels of orthophosphate were higher in the eastern sector of the loch. These elevated orthophosphate figures were not accompanied by higher levels of N, which was barely measurable at these locations; this part of the loch is surrounded by blanket bog and there was no apparent explanation for the figures (Scott *et al.*, in prep.).

Loch an Duin has a catchment of blanket bog, heather moor and rock. There are two roads and a disused quarry in the catchment, but no houses. A plantation of Sitka spruce and lodgepole pine to the west of the loch comes as close as 15 m to the shore. There seem to be no current impacts from the plantation, but care in felling will be required to minimise silting of Loch an Duin.

The catchment of Loch an t-Sruith Mhoir is also largely blanket bog, heather moor and rock. Because land levels are so generally flat, it is difficult to establish the precise boundary of the catchment, but it could include up to 20 houses; it is likely that most of these have septic tanks discharging to the sea rather than to the lagoon (Scott *et al.*, in prep.).

Within a suitable salinity range, the main constraint on bird’s nest stonewort distribution appears to be the availability of a sandy substrate kept clear of other vegetation by bioturbation, chiefly from lugworms (*Arenicola marina*), but also from fucoid seaweed movement. The effects of bioturbation from lugworms in saline lagoons can be substantial, even where the worm occurs at low densities (Sheader, 1995).

Fig 5. Distribution of Bird’s nest stonewort in Loch an Duin, North Uist.
Lessons Learnt, Further Work and Future Recommendations

North Uist

Healthy populations of bird’s nest stonewort were confirmed in both North Uist lochs, and there are few concerns that current catchment management presents any threat to these populations. Only future felling of a plantation near Loch an Duin may be significant, but careful management of felling operations may avoid siltation of the lagoon.

Both lochs offer a wide range of salinity, which fluctuates widely at any individual location. Within the wide salinity limits tolerated by bird’s nest stonewort the main constraint on distribution and abundance seems to be the availability of open sandy substrate, and this appears to exist as a result of bioturbation, mainly due to burrowing by lugworms. Martin (2001) established that spore production in foxtail stonewort was greatest where salinity fluctuation was greatest, but there is no comparable information for bird’s nest stonewort. The 2009 survey (Scott et al., in prep.) showed that although bird’s nest stonewort was more widely distributed than the other stoneworts, it was more localised within this range. It is possible that foxtail stonewort in particular could gain at the expense of bird’s nest stonewort, and some fluctuation between the abundance of the two is to be expected. At present it is not known what variables could affect any competition between them, but monitoring will be required to confirm that the foxtail stonewort (which is very rare nationally) does not adversely affect the (even rarer) bird’s nest stonewort.

Bird’s nest stonewort is widespread in Northern Europe, mainly in the Baltic Sea, where it is scattered around most of the open coast. Climate change is expected to result in a reduction in salinity in the Baltic due to increased river run off (Baltadapt, 2011). The opposite is predicted to occur in the Uists, where relative sea level rise has recently been recorded as 6 mm per year (Rennie and Hansom, 2011). This is likely to lead to a gradual increase in the salinity of saline lagoons in the Uists and Orkney (Angus et al., 2011; Angus, 2013). The relationship between rising sea levels and loch salinity is complex: when the halocline is established, new sea water will flow into the lower level on each high tide, while water from the less saline upper layer will discharge to the sea at low tide. Stratification is broken down by wind-induced turbulence, and any increase in windiness above the threshold level that leads to halocline breakdown (i.e. not necessarily at the level of ‘storminess’) could affect salinity levels, thus rising sea level is not the only aspect of climate change with a possible impact on lagoon functionality and biota.

It is clear that both bird’s nest stonewort sites have ample habitat range within their salinity tolerance to allow for continuity of occupation, at least within the medium term. However, the change in salinity could lead to a competitive advantage for other species over bird’s nest stonewort, particularly in respect of its requirement for disturbance. It will thus be necessary to monitor bird’s nest stonewort and relevant environmental attributes on a regular basis to ensure that its status is retained. Should any reduction in extent be detected, it might be possible to introduce disturbance or manage the saline inflow, but these approaches could feature in a wider debate on adaptation v. resistance in respect of coastal management: at what stage does habitat or species management become ‘resistance’, and in what circumstances can resistance be justified? However, lugworms have a wide salinity tolerance and can live at high density in full or even slightly hypersaline sea water (Shedder 1995), so it is highly likely that current levels of bioturbation can be maintained unless other plant species achieve wider cover. The 2009 survey also detected some bioturbation from fucoid fronds at the edge of clumps, providing clear mud for bird’s nest stonewort to become established.

Orkney

Even assuming that a salinity level close to zero might be a suitable environment for bird’s nest stonewort, Loch of Boardhouse probably no longer presents a suitable location for a reintroduction: the change in trophic status, the density of algae and the proliferation of the alien invasive Canadian pondweed (Elodea canadensis) all combine to reduce the chances of successful re-establishment. The changes in salinity and circulation in Loch of Stenness also suggest that conditions might be less than favourable for re-establishment, but there remains a small possibility that bird’s nest stonewort survives undetected there.
Conclusions

It is thus concluded that there are limited possibilities of re-establishment at former sites, with a small chance of success in the Loch of Stenness. Bird’s nest stonewort maintains healthy populations at both its existing sites and prospects for these seem to be good, with some possibility of indirect impacts from climate change. The best chances for future survival rely on regular monitoring, with no recommendation at present for translocation or active intervention in habitat management, though any significant decline recorded by monitoring might require a re-assessment of these conclusions.

Further Information


References


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The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Intermediate Wintergreen

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Summary

- **Intermediate wintergreen** – this evergreen perennial herb is associated with submontane heather – bearberry heathland, and Scots pine and birch woodland. Following a significant UK decline, this species is now largely confined to the central and eastern Highlands of Scotland, with a stronghold in the Cairngorms area.

- **Action during the Species Action Framework (SAF)** – research was undertaken to establish its current distribution, and gather vital information on its habitat and management requirements. Targeted recording was promoted in the Cairngorms National Park which revealed that this species is more abundant here than previously realised.

- **Habitat requirements** – a diverse structure within the field layer, including short, open areas of vegetation, with a degree of localised ground disturbance, promotes the persistence and spread of intermediate wintergreen. In woodland, it is associated with clearings, gaps and edges, and more open stands, indicating that excess canopy shade is limiting.

- **Local distribution and management** – this species is most abundant where suitable open field layer conditions are maintained in heathlands managed by rotational muirburn, where some very extensive populations can occur, and in heaths and open woods moderately grazed by livestock or deer. Elsewhere, its occurrence is more restricted, and often confined to track-edge sites or open, wind-clipped vegetation and rocky areas on steep slopes and at higher levels.

- **Conservation management** – active heathland management, via controlled burning, moderate grazing, or alternatively brush-cutting and light scarifying, will help to conserve intermediate wintergreen as a component of the heathland communities in which it occurs. Management to diversify woodland structure, especially in plantation sites, will enhance the availability of suitable habitat, but this must be accompanied by moderate grazing, or alternative sporadic disturbance of the field layer, to create and maintain areas of suitable open vegetation.

- **Future recommendations** – low grazing and disturbance levels are a key constraint on intermediate wintergreen, and other associated ground flora, in many pinewoods. Long-term action is required to address this, including woodland cattle-grazing trials. Key lessons learned in the Cairngorms area should be applied to sites outside the Park where the decline of intermediate wintergreen has been most severe.

Introduction

**Species background**

Intermediate wintergreen (*Pyrola media*) is an evergreen perennial herb with round, shiny dark-green leaves arranged in loose rosettes. It flowers in late June and July when the white/pink globe-shaped flowers (7–11 mm wide) are borne in a loose cluster at the top of the flowering stem (15–30 cm tall, Fig. 1). This nationally scarce species is classified as ‘vulnerable’ on the Red Data List for Great Britain (Cheffings and Farrell, 2005) and is included on the Scottish Biodiversity List.

Fig 1. Intermediate wintergreen

© Laurie Campbell/SNH
Why was it on the SAF list?

Intermediate wintergreen met criterion 1a of the SAF, as a species for conservation action (SNH, 2007). It has suffered a significant decline across Britain since the 1970s, and its stronghold lies within Scotland. It was considered that targeted action could make a difference and that improved management of its heathland and woodland habitats would also benefit other species, including two other related wintergreens.

Habitat, distribution and abundance

Intermediate wintergreen occurs in heathland and open woodland on mildly acidic to slightly basic, free-draining soils from near sea level to 550-600 m altitude.

It shows a close association with submontane heather (*Calluna vulgaris*) — bearberry (*Arctostaphylos uva-ursi*) heathland (NVC type H16), a vegetation type largely confined to the northeast of Scotland thought to be derived from former woodland. It can also be found in heather – blaeberry (*Vaccinium myrtillus*) heath (H12) and heather – bell heather (*Erica cinerea*) heath (H10). It occurs regularly in Scots pine (*Pinus sylvestris*) woodland (W18), as well as birch (*Betula spp.*) woodland (W17) and juniper (*Juniperus communis*) scrub (W19), in association with species including creeping lady’s-tresses (*Goodyera repens*), chickweed wintergreen (*Trientalis europaea*), common wintergreen (*Pyrola minor*) and, occasionally, twinflower (*Linnaea borealis*) (see Rodwell, 1991a, 1991b for NVC community descriptions).

Within Britain, intermediate wintergreen is now largely confined to the eastern and central Highlands of Scotland where its distribution is still relatively widespread. Scattered records extend to the northern Highlands and over to the west coast and north of Skye. Its stronghold lies within the Cairngorms National Park. Outside the Scottish Highlands, this species is scarce. It is known from only a few localities in southern Scotland, northern England and Wales.

General ecology

Intermediate wintergreen is clonal, spreading by short rhizomes which creep underground, and occurs in discrete patches or scattered clusters of rosettes. It is often described as ‘shy-flowering’ and, typically, only a small proportion of rosettes in a patch will produce a flowering spike in a given year.

The flowers are adapted for pollination by bumblebees, but can also automatically self-pollinate in the absence of pollinators (Knudsen and Olesen, 1993). Following pollination, the ovary of each flower swells and ripens to produce a dry, dehiscent capsule containing several thousand dust-like seeds, released in late September and October, and capable of long-distance dispersal by wind. Bare or disturbed ground is required for seedling establishment, but once established it can persist and spread by vegetative reproduction amongst closed vegetation. Its growth is suppressed by shade from dense overtopping dwarf-shrubs in the surrounding field layer.

This species is capable of vegetative re-generation after fire, re-growing from dormant buds on underground rhizomes (Mallik and Gimingham, 1983), and finds its place amongst heathland communities shaped by the widespread use of rotational muirburn for several centuries. Its roots form associations with a diverse range of mycorrhizal fungi, including species typically associated with Scots pine, birch and ericoid dwarf-shrubs (Toftegaard et al., 2010). Recent evidence suggests that some *Pyrola* spp. are ‘mixotrophic’, gaining additional carbon from the ‘fungal network’ as well as that obtained via photosynthesis in their own leaves (Tedersoo et al., 2007).

History of decline, contributory factors and current threats

Intermediate wintergreen has suffered a significant decline in its recorded UK distribution since 1970. Decline is most significant on the periphery of its UK range, notably in northern England and the south and east of Scotland, where records for the species have always been relatively scarce. However, some evidence of decline is also apparent within its Highland stronghold.

A likely cause of decline has been the loss and degradation of traditionally managed heathlands in which this species occurs. Significant losses of these heaths have occurred since the 1950s where grouse moors and extensive livestock grazing had become less economically viable and/or where management objectives had changed in favour of afforestation. Where regular burning and grazing have ceased, the field layer becomes increasingly dominated by uniform tall and dense heather, flowering herbs are largely excluded, and encroachment of scrub and woodland can occur.
Heavy grazing of heathlands is equally damaging, especially by sheep, and palatable herbs such as intermediate wintergreen can be completely ‘grazed-out’. Where prolonged heavy grazing occurs, the dwarf-shrub heath in which intermediate wintergreen is found can be lost to grassland. Further damage to heathland plant communities can be caused by high intensity fires during muirburn, preventing them from regenerating fully after fire (see Hobbs and Gimingham, 1984). The recent trend towards burning larger patches of heather less often, compared to the more traditional practice of burning smaller patches on a more frequent rotation, may also be driving species loss in these heaths.

Woodland management practices are also likely to have contributed to this decline. In particular, the planting of uniform stands of closely-spaced trees or the encouragement of prolific natural regeneration can result in dense woodland that casts heavy shade on the field layer below, restricting all but the most shade-tolerant of plants to occasional gaps and edges. The problems of over- and under-grazing and resulting impacts on the condition of the field layer, as described for heathlands, are also mirrored in woodland systems.

It is also conceivable, and quite likely, that some of the apparent decline of intermediate wintergreen may be due to historical recording errors for the closely related common wintergreen with which intermediate wintergreen can be easily confused, especially in a non-flowering state. Recent developments in vegetative identification of wintergreens (see Poland and Clement, 2009) along with genetic markers, which can be used to distinguish between closely related *Pyrola* spp. (Squirrel et al., 2011), have increased the reliability of identification of non-flowering wintergreens in recent years.

**Aims**

**Aims for 2007-2012**

The principal aims of the SAF project were to maintain and, where appropriate, enhance existing populations of intermediate wintergreen; and to restore it to former sites, through re-establishment of suitable woodland and heathland management.

Types of action included:

- Produce an advice note on good management practice for the species and its habitats.
- Identify key sites for habitat restoration and instigate appropriate management practices with partners through existing or tailored schemes.

**Management Action**

**Summary of the main actions carried out**

- **Genetic markers** – developed by the Royal Botanic Garden Edinburgh and James Hutton Institute in 2007, these provide a tool to assist with the identification of non-flowering wintergreen populations and an insight into levels of genetic diversity.
- **Review of UK distribution** – a sample of historical records were re-visited by the Botanical Society of Britain and Ireland (BSBI) Threatened Plants Project in 2008, to establish the current distribution of the species in the UK and determine evidence of decline.
- **Targeted recording and research** – since March 2010 action has been undertaken by the Cairngorms Rare Plants Project to increase knowledge of the distribution, habitat, and management requirements of intermediate wintergreen in the Cairngorms National Park.
- **Habitat management trials** – these are ongoing at sites in the Cairngorms National Park, to investigate the potential of targeted field-layer management to restore and maintain favourable conditions for this species.
- **Guidance on management** – a guide to Managing Scotland’s pinewoods for their wild flowers (including intermediate wintergreen) was produced by Plantlife in 2011.

**Understanding the distribution, ecology and management requirements of intermediate wintergreen in the Cairngorms National Park**

Intermediate wintergreen was one of four of Scotland’s threatened plants selected for targeted action by the Cairngorms Rare Plants Project, which commenced in March 2010. The target area for
this project was the Cairngorms National Park (the Park), the current UK stronghold for intermediate wintergreen.

Up until the last decade or so, detailed botanical records for intermediate wintergreen were scarce, both within the Park and the rest of Scotland, with the plant typically being recorded as present within hectads (10-km squares) and tetrads (2-km squares), or at best monads (1-km squares), with few records for individual sites or populations (i.e. 100 m grid references or better) and a lack of associated monitoring information. In addition to this, there was little information on the specific habitat and management requirements of this species.

In order to gather baseline information, and to better understand the conservation requirements of the species, the Cairngorms Rare Plants Project set out to do the following:

1. Establish the current distribution of intermediate wintergreen in the Park – by recruiting and training volunteers, and enlisting the help of local wildlife recorders, targeted recording of intermediate wintergreen was promoted within the Park and searches were undertaken for plants using historical records and in areas of potentially suitable habitat. For each population (re-) found, accurate GPS location and monitoring data was collated. Identification was verified using vegetative or floral characters in the field and from photographs submitted with records.

2. Review management regimes and population status – detailed surveys were undertaken, including an MSc student project at the University of Aberdeen (Mielke, 2011), to gather information on the status of intermediate wintergreen populations in relation to habitat conditions and management regimes at a wide range of sites in the Park.

3. Secure favourable management and implement recovery action – findings from surveys were utilised to develop management guidelines and inform land managers of the location of significant populations of this species on their land. Trials were set up to test the potential application of brush-cutting and controlled burning as a means of restoring favourable field-layer conditions for intermediate wintergreen. Baseline monitoring data were incorporated into these trials, and other ongoing heathland restoration work, to track long-term population changes in response to management.

**Distribution and status**

Over the course of three field seasons, between 2010 and 2012, more than 300 records were made for intermediate wintergreen in the Cairngorms National Park. These equated to 28 hectads (10-km squares), 137 monads (1-km squares) and 238 unique 100 m records. Targeted recording has significantly increased our knowledge of the distribution of intermediate wintergreen in the Park and has highlighted, undoubtedly, that this species was previously under-recorded in this area (Fig. 2).

Combined with data from the BSBI Distribution Database, intermediate wintergreen has been recorded from a total of 38 hectads, 163 monads, and 310 unique 100 m records in the Park since the year 2000 (Table 1). In the context of Scotland as a whole, the significance of the Cairngorms National Park as a remaining stronghold for intermediate wintergreen has become increasingly apparent with 44% of hectad, 65% of monad and 71% of unique 100 m records made since the year 2000 falling within this area. Unlike the rest of Scotland, there is little evidence to suggest a significant decline here since 1970 (Table 1).

Within the Park, intermediate wintergreen has a widespread distribution with a concentration of records along Deeside and Strathspey (Fig. 2), where it can even be described as locally frequent in some areas. Records in the north-east and south-west of the Park are more occasional and scattered, but this may partly reflect lower search effort in these areas. Its range here extends from lower altitude heaths and woodlands, around 150-200 m, through the forest zone to submontane heath and scrub, reaching an altitudinal limit of 550-600 m. No recent records have been made above 600 m.

Small patches were by far most common, with counts of 100 rosettes for 66% of records submitted and 500 rosettes for 90% of records. However, some very large patches containing 1000s of rosettes were also recorded. Studies of the genetic diversity of intermediate wintergreen populations in pinewoods revealed that individual patches typically contain only one or a few genetic individuals (Squirrell et al., 2011). This highlights that vegetative (or clonal) reproduction plays a significant role in the maintenance and local spread of individual patches, and recruitment from seed within patches may be infrequent.
Habitat and management requirements: heathland

Intermediate wintergreen was recorded most frequently in ‘dry heath’, and very often in heather–bearberry heath (Fig. 3) confirming its close association with this community. Many of these sites have a long history of rotational muirburn management and/or extensive grazing by livestock or red deer. Some of the largest and most extensive populations of intermediate wintergreen in the Park are found in managed heathlands, where this species can be a frequent component of heather–bearberry heathland (Fig. 3), especially where this occurs over less base-poor soils.

Table 1. Past and present records for intermediate wintergreen in Scotland and the Cairngorms National Park (CNP). Missing data (–) for monad and 100 m records reflect low resolution of historical records.

<table>
<thead>
<tr>
<th>Unique Records: Scotland</th>
<th>Unique Records: CNP</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>10km</td>
</tr>
<tr>
<td>Pre-1970</td>
<td>187</td>
</tr>
<tr>
<td>1970–1999</td>
<td>129</td>
</tr>
<tr>
<td>2000–2012</td>
<td>87</td>
</tr>
</tbody>
</table>

Historical records © Botanical Society of Britain and Ireland.

Fig 2. One-km square distribution of intermediate wintergreen (1987–2012) in the Cairngorms National Park, showing records since 1987 (dark-blue squares) and only since 2010 (purple squares).

Map created by Andy Scobie.
This species is able to withstand muirburn, where fires are not too severe, and has a strategy which enables it to regenerate and spread effectively amongst open post-burn conditions. Leaf rosettes reappear quickly, in the first and second growing seasons after fire, as regeneration from underground rhizomes takes place. Subsequent vegetative spread and flowering are promoted in the open field-layer conditions that persist for several years following fire. Fire also creates bare patches of ground, providing open sites for seedling recruitment, enabling potential for spread both within and between burnt patches.

As time since burning increases, the surrounding dwarf-shrub vegetation closes in and heather re-attains its dominance. Conditions gradually become less favourable for intermediate wintergreen, and other flowering herbs, amongst the increasingly tall and dense field layer. During this phase, intermediate wintergreen populations are often reduced to very low densities, persisting as occasional scattered rosettes in gaps amongst tall heather, and flowering is often infrequent. Vegetative persistence plays a key role in the maintenance of these populations until the next fire event occurs.

Rotational muirburn provides a regular source of disturbance in managed heathlands, creating a mosaic of vegetation of varying ages as well as preventing succession towards woodland or scrub. This regular disturbance, and maintenance of open patches of vegetation and bare ground, promotes the persistence and spread of intermediate wintergreen, leading to its frequent occurrence in managed heathlands in some areas. These populations are somewhat dynamic and rise and fall within the heathland landscape in response to patterns of burning over time.

In a similar but typically less uniform fashion, regular grazing of heathlands creates a variable structure within the field layer, maintaining areas of suitable short, open vegetation for intermediate wintergreen and associated flowering herbs. Disturbance from animal hooves also provides a source of bare ground for seedling establishment and spread. Moderately grazed heaths, where there is no history of muirburn, can also support significant populations of intermediate wintergreen.

Away from heathland shaped by regular grazing or fire, the occurrence of intermediate wintergreen is typically more restricted. Here, it is found in small and discrete, often isolated, patches. These patches are often associated with open, rocky areas or wind-clipped vegetation on steep slopes, banks and knolls, ridges and summits of hills (<600 m), and the edges of animal tracks and footpaths, where there is some openness amongst the field layer or a localised source of ground disturbance.

Small, widely scattered patches of rosettes can persist amongst tall heather at sites that previously sustained heavier grazing levels or fire, and evidence suggests they can do so for several decades, reflecting more favourable conditions in the past. These residual populations could act as a potential source for recolonisation if suitable conditions are restored.

**Habitat and management requirements: woodland**

Intermediate wintergreen is also regularly recorded from woodland, most often semi-natural and planted Scots pine woodland, but also birch woods and juniper scrub. In woodland it is associated with edges, clearings and gaps, or more open stands, rarely occurring under a closed canopy, indicating that excess shade is limiting. Similarly to heathland sites, the local occurrence and abundance of intermediate wintergreen in woodland is also influenced by grazing and disturbance levels.

This species is frequently associated with the edges of animal tracks, footpaths and forest tracks in woodland, and is locally frequent along track sides and banks in a number of old pinewoods in Strathspey (Fig. 4). Here, it occurs in discrete patches of rosettes, often in open, mossy and herb-rich areas amongst the dwarf-shrub field layer. In some woods, intermediate wintergreen is entirely confined to track-edge sites, highlighting the importance of this source of open and disturbed ‘forest-edge’ habitat within these woodland systems.
Fig 4. Low grazing and disturbance levels limit suitable open field-layer conditions for intermediate wintergreen, which is consequently confined to track-edge sites in many pinewoods.

© Andy Scobie

Its occurrence is less restricted in moderately grazed open woodland, where a diverse structure is maintained within the field layer along with ground disturbance associated with grazing animals. It also occurs at or near the upper limit of woodland growth, amongst mosaics of broken woodland cover, juniper scrub and open heath, where exposure, steep slopes and grazing animals maintain openness and disturbance amongst the field layer. It has also been recorded in a number of instances under lone ‘granny pines’ in open heathland, reminiscent of an association with former native woodland.

Most of the pinewood sites where intermediate wintergreen occurs were historically subjected to periods of grazing by domestic livestock, especially cattle, and/or previously sustained higher grazing pressure from red deer (Steven and Carlisle, 1959). Very few of these woods are currently grazed by livestock, and plantations are often fenced to exclude all grazing animals. In many of the more extensive remnants of semi-natural pinewood across the Park, red deer numbers have been significantly reduced as part of management to promote woodland restoration and expansion.

While action to control grazing is clearly necessary to enable natural woodland regeneration in some areas, a consequence of the dramatic reduction in grazing levels has been the widespread development of tall and dense field-layer vegetation in these woods and associated open habitats. It is here that short, open vegetation and disturbed ground are most limited and the growth and spread of intermediate wintergreen, and other associated ground flora, is often severely constrained by unfavourable habitat conditions.

Lessons Learnt, Further Work and Future Recommendations

New and ongoing work since SAF ended

The James Hutton Institute has monitored inter-year variation in flowering success at a range of mainly woodland sites with contrasting light conditions. Results indicate significant inter-year variation.
Key Management Messages

A closer look at the fine-scale distribution and abundance of intermediate wintergreen in the Cairngorms National Park has revealed some key messages in relation to its future conservation management, both within the Park and the rest of Scotland. The following bullet points provide a summary of the key management messages and recommendations for the future:

• Intermediate wintergreen requires areas of short, open vegetation within the field layer and bare or disturbed ground for persistence and spread, along with clearings, gaps and ‘edge’ habitat within continuous woodland stands. Given its capacity for vegetative persistence and spread, and wind-dispersed seeds which can potentially be transported over long distances, it seems likely that this species exhibits a naturally ‘patchy’ distribution, reflecting patterns of grazing and disturbance within the wider landscape.

• Rotational muirburn and the action of large grazing animals can maintain suitable open field layer conditions and bare or disturbed ground required by this species. The maintenance, or reinstatement, of well-managed areas of dry heath, either by grazing, controlled burning, or alternatively heather cutting and light scarification, whilst avoiding overgrazing, will help to conserve intermediate wintergreen and the heathland communities in which it occurs. The close association of this species with submontane heather – bearberry heath means that wider work to conserve this community is also likely to benefit intermediate wintergreen.

• Upland heathland managed as red grouse moor and hill grazings for livestock and red deer is widespread in the Cairngorms National Park. The future of intermediate wintergreen as a component of these heathlands seems relatively secure and there is little need to extend this already widespread management to new areas. However, heathland at lower levels in the Cairngorms area and elsewhere in Scotland has a greater history of loss and degradation due to over- or under-grazing, agricultural improvement, and afforestation. The decline of intermediate wintergreen has been most notable from these sites, both within Scotland and the rest of the UK. Identifying, maintaining and restoring good examples of such heathland with local remnant populations is a high priority for conservation.

• In woodland, the requirements of intermediate wintergreen highlight the importance of managing for a diverse spatial structure, along with mosaics of woodland and open habitat, to create essential variation in the light regime. The benefits of variable-density thinning and re-structuring of uniform pine plantations, managing for natural regeneration as opposed to re-planting, and the incorporation of clearings and sparsely stocked areas when re-planting or establishing new woods, have all been well promoted in relation to the enhancement of woodland biodiversity, and apply equally to specialist plants associated with woodland habitats (see Scott, 2011).

• Conditions within the woodland field layer are also of critical importance. In many pinewoods and associated open habitats, low grazing and disturbance levels, leading to the development of rank field layer vegetation, a deep moss layer or little bare ground, are key constraints on the persistence and spread of intermediate wintergreen and other species such as twinflower. This problem is most notable at sites where grazing levels have been significantly reduced to promote woodland regeneration.

• At woodland sites where these issues are apparent, long-term management plans should recognise the need to restore slightly higher, but sustainable, grazing levels in the future (whether by red deer or livestock), once target levels of regeneration have been achieved. Alternatively, and in the shorter term, management to mimic sporadic disturbance of the field layer, via brush-cutting, light scarifying or carefully controlled burning, especially in more open areas, should be further tested and applied (Fig. 5). Extra care is required when using fire as a management tool at new sites to avoid damage to woodland and remnant populations of other rare species less tolerant of fire, including twinflower.
Cattle grazing is another potential solution, especially for more accessible sites, and preferable to sheep which have a tendency to target more palatable vegetation and are lighter so have less of a trampling impact on tall heather. Grazing needn’t be regular; sporadic heavy grazing to create a variable mosaic of vegetation within the field layer could be equally beneficial. To date, few studies have directly tested the impact of cattle grazing on the pinewood field layer (Hancock et al., 2010). New long-term management trials are required to establish best-practice and monitor resulting impacts on woodland ground flora, in both plantation and semi-natural woodland sites.

Outside the Cairngorms National Park, where intermediate wintergreen is arguably most threatened, little has been done to secure remaining sites. Lessons learned from this study should be applied to sites beyond the Park boundary.

Further Information

- [www.cairngormsrareplants.org.uk/index.php/the_species/31](http://www.cairngormsrareplants.org.uk/index.php/the_species/31) – Cairngorms Rare Plants Project website page on intermediate wintergreen.
- [http://sppaccounts.bsbi.org.uk/content/pyrola-media-1](http://sppaccounts.bsbi.org.uk/content/pyrola-media-1) – BSBI website page on intermediate wintergreen.

References


Mielke N. 2011. *What factors influence the presence and abundance of intermediate wintergreen (Pyrola media) in the Cairngorms National Park and how do these relate to current and historical site management?* MSc thesis, School of Biological Sciences, University of Aberdeen.


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**The SAF Partners**

- Scottish Natural Heritage
- Cairngorms National Park Authority
- University of Aberdeen
- Botanical Society of Britain and Ireland
- Plantlife
- Royal Botanic Garden Edinburgh
- James Hutton Institute

**The Species Action Framework Handbook**

This account comes from the *Species Action Framework Handbook* published by Scottish Natural Heritage. For more information on the handbook please go to [www.snh.gov.uk/speciesactionframework](http://www.snh.gov.uk/speciesactionframework).

Lesser Butterfly-orchid

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Summary

• Lesser butterfly-orchid was included in the Species Action Framework (SAF) as it had suffered a 33% decline in Great Britain between 1964 and 2002, leaving Scotland as its stronghold. This SAF project was carried out by a partnership of Scottish Natural Heritage (SNH), the Botanical Society of Britain and Ireland (BSBI), Plantlife and the Cairngorms Rare Plants Project (CRPP).

• Survey was a key activity, as little was known about current distribution and individual sites before the SAF project. A Scottish national survey by volunteers between 2006 and 2012 identified over 500 sites. Valuable information was gathered on the species’ ecology and the land management that benefits it.

• The survey established the current distribution of lesser butterfly-orchid in Scotland. This follows the historical distribution, being commonest in the north-west and the Hebrides.

• There is evidence of a recent decline in parts of Scotland where the orchid has always been uncommon, in southern and north-east Scotland, mid-Perthshire and parts of Argyll.

• Most sites have fewer than 10 flowering plants; a few exceptional sites have more than 100 and three sites can have more than 1,000 in a good year.

• Actions taken during the SAF project included annual monitoring by Plantlife Flora Guardians, a management survey of selected sites, and preparation of a Management Guide for land managers on best management practice.

• Lesser butterfly-orchid grows in a wide range of habitats, therefore a single management prescription is not suitable for all sites. Although generic guidance can be given, sites should ideally be assessed individually and advice tailored to the condition of the site.

• Grazing levels are the most important management tool for the orchids, which are vulnerable to both under- and over-grazing, especially during flowering. Drainage patterns and flushing are important factors at many sites.

• Active management to improve conditions for the orchid has been initiated at several sites. This includes, for example, restoration work on failing sites by the Scottish Wildlife Trust (SWT) and by CRPP in the Cairngorms National Park.

• Lesser butterfly-orchid is a flagship species for ecologically important sites that are vulnerable and easily lost through changes in management. It often grows with other orchid species and was found with rare and declining orchid species such as small white-orchid. It occurs on unimproved, marginal agricultural land, reclaimed land, heathland and moorland. Many sites are being managed in a traditional way and this should be encouraged by appropriate financial support schemes, such as the Scotland Rural Development Programme (SRDP).

• More than 90% of lesser butterfly-orchid’s known sites are not designated. While additional protection for certain key populations is needed, it is clear that site designation alone will not maintain the conservation status of the species, so that wider countryside measures are also required to prevent habitat loss and stop species decline.

• The project has engendered a great deal of interest and enthusiasm across Scotland for the conservation of this charismatic species. It will be important to harness this to try and reverse the orchid’s historic decline.
Introduction

Species background

Lesser butterfly-orchid (*Platanthera bifolia*) is a beautiful, delicate white orchid with a flowering stem 15-30 cm tall (Fig. 1). The flowers are creamy white tinged with green, with a long, straight undivided lip and slender spur, 13-23 mm long. There are two large oval, sub-opposite leaves at the base of the flowering stem, giving the species name ‘bifolia’, and one to five narrower more pointed upper leaves. It grows from a pair of underground tubers. In Scotland it flowers from mid-June to early July, with a sweet scent that attracts night-flying moths, which are thought to be the main pollinators. The seed pods develop slowly after flowering and may not ripen and shed seed until mid-October.

Lesser and greater butterfly-orchids - telling them apart

Lesser butterfly-orchid may be confused with its close relative, the greater butterfly-orchid (*Platanthera chlorantha*); the two species grow close together on several Scottish sites. The most reliable way to tell them apart is to look at the two little sacs of pollen grains, the pollinia, in the mouth of the flower. In lesser butterfly-orchid the pollinia are parallel (Fig. 2). In greater butterfly-orchid the pollinia diverge from a central point to form an inverted V shape (Fig. 3).

Fig 1. Lesser butterfly-orchids.
© Stewart Taylor

Fig 2. Lesser butterfly-orchid – note the parallel pollinia sacs.
© Andy Scobie

Fig 3. Greater butterfly-orchid – note the spreading pollinia sacs.
© Andy Scobie
Why was this species on the SAF List?

Lesser butterfly-orchid suffered a decline across Britain between 1964 and 2002 with Scotland now the main stronghold for the species. It is vulnerable, as habitat loss is a continuing threat to the species in the UK, and is listed as ‘Vulnerable’ in the GB Red Data List (Cheffings and Farrell, 2005). It receives a level of protection, as do other wild plant species, under the Wildlife and Countryside Act 1981 (as amended), although is not listed on Schedule 8. Those plants that occur on SSSIs should receive additional protection through legislation affecting designated sites. It was listed as a Priority Species under the UK Biodiversity Action Plan (UKBAP) in 2007 and is included on the Scottish Biodiversity List, although this does not give the species statutory protection.

Habitat, distribution and abundance

Little was known about Scottish sites for lesser butterfly-orchid before the SAF project. A national survey was launched by SNH in 2006 to find out more about its current status and distribution (Lavery, 2007). Members of the public were asked to submit information about their sightings to a website or on forms to SNH. The records were validated and collated. Information provided included grid references, site names and descriptions including area, associated vegetation, population of the orchid and land management. The survey continued every year to 2012. Over 300 volunteers contributed nearly 900 records for 597 sites during the six years of the project.

Lesser butterfly-orchid occurs in a variety of habitats: heathland, wet grassland, herb-rich grassland, reclaimed land on shale and lime spoil, open scrub, woodland edges and moorland. It is tolerant of wet conditions and is frequently found on tussocks in marshy grassland or on the edge of flushes in heathland and upland sites. The orchid occurs along road verges in the north-west and the Hebrides. It grows on a range of soil types, from mildly acid to calcareous soils, overlying sands, gravels and clays.

The national survey confirmed that this is a relatively widespread species in Scotland, especially along the west coast, on the Hebrides and north of the Great Glen. It has always been a relatively rare species in the south-west and is now almost absent from south-east Scotland (Fig. 4). Most hectads (10 x 10 km squares of the National Grid) have only one or two site records but a few hectads in the north and west have as many as 12 sites. In the rest of the British Isles, it is scattered in west Wales, north-west and south-west England, Northern Ireland and central Ireland. It occurs throughout Europe, the Caucasus, northern Asia and North Africa.

The total population size in the UK is unknown but is likely to be in the tens of thousands. However in Scotland, it is not usually found in dense stands and populations of over 100 individuals are rare, with groups containing just a few plants being more usual. More than 60% of sites reported in the survey had fewer than 10 flowering plants. Fewer than five sites had more than 500 flowering plants and only three sites had more than 1,000 (Table 1). Fig. 5 shows the geographical distribution of flowering plant population sizes in Scotland. This suggests a maximum Scottish population of 30,000 flowering plants.
Table 1: Number of lesser butterfly-orchid sites in each population size class recorded during the Scottish national survey 2006-2011.

<table>
<thead>
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<th>Population size (flowering plants)</th>
<th>No count</th>
<th>1-10</th>
<th>11-50</th>
<th>51-100</th>
<th>101-300</th>
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</thead>
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<tr>
<td>Number of sites</td>
<td>73</td>
<td>296</td>
<td>105</td>
<td>29</td>
<td>22</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>539</td>
</tr>
</tbody>
</table>

Fig 5. Flowering plant population sizes and distribution in Scotland, 2000-2011.

Key to geographical divisions
NW & N: Scotland north of the Great Glen fault (Vice-counties 97, 103-112)
NE: North East Scotland, Cairngorms and Aberdeenshire (Vice-counties 91-96)
East: East Scotland, north of the Forth/Clyde rivers (Vice-counties 85, 89, 90)
Central: Central Scotland, north of the Forth/Clyde Rivers (Vice-counties 86-88, 99)
West: West Scotland, north of the Forth/Clyde Rivers (Vice-counties 98, 100-102)
SE: East Scotland, south of the Forth/Clyde to the border (Vice-counties 78-84)
SW: West Scotland, south of the Forth/Clyde to the border (Vice-counties 72-77)
**General ecology**

The numbers of flowering spikes vary between sites but also from year to year at the same site. Plants do not produce flowering spikes every year and in some years may only produce basal leaves or remain dormant as tubers underground. Experiments have shown that it takes about four years from sowing seed to flowering. A short open sward that allows seeds to fall onto the soil surface is needed for successful germination. Germination benefits from light poaching, or activities such as ditching, that provide new patches of bare soil. Each capsule can produce many thousands of seeds and if conditions are suitable many seedlings can grow from a few flowering spikes.

Mature plants cannot compete with dense grasses or withstand shading from tall vegetation and scrub, such as gorse, broom and seedling birch. This is apparent at sites where there has been a serious population decline and where recent scrub growth had occurred. Appropriate grazing or cutting was found to be crucial to the success of orchids at many sites with larger populations. Early or late mowing of roadside verges, avoiding removal of flowering spikes while keeping the sward short, help keep verge sites in good condition, with the short open sward encouraging germination (Long, 2010).

Lesser butterfly-orchid is a key indicator for several important plant communities and it is mentioned in the citation for many SSSIs rich in orchid species. The national survey found that it frequently occurs with one or two other orchid species and in some instances up to seven others. These include two nationally scarce species, small white-orchid (*Pseudorchis albida*) at several sites and Irish lady’s-tresses (*Spiranthes romanzoffiana*) at one site. Lesser butterfly-orchid grows in close association with devil’s-bit scabious (*Succisa pratensis*) at many sites (Fig. 6), with orchid plants sometimes growing out of dense clumps of scabious leaves. Devil’s-bit scabious is present in all the plant communities in which lesser-butterfly orchid was recorded during the national survey (Rodwell, 1991a, 1991b, 1992). Devil’s-bit scabious is also important in the lifecycle of another SAF species, the marsh fritillary butterfly (*Euphydryas aurinia*).

**History of decline, contributory factors and current threats**

Lesser butterfly-orchid suffered a 33% decline in hectad distribution across Britain between 1964 and 2002, with many losses in England before 1930, in contrast to Scotland (Preston et al., 2002). Drainage of fields, woodland extension or disturbance, ploughing of grassland and heathland, spreading of fertilizers, spraying with herbicides, heavy grazing during the summer, and cutting of roadside verges in the flowering season are activities that have destroyed habitats and caused decline. Under-grazing and the subsequent conversion of sites to tussock-forming grasses, dwarf shrubs and scrub is also a significant cause of decline. All of these pressures still exist, and the Scottish national survey indicates that the species frequently occurs on sites that are potentially vulnerable to loss of suitable habitat.

Many sites are on marginal agricultural land managed in a traditional way. The majority of upland heathland and moorland sites are ungrazed or lightly grazed by sheep and deer.

**Recent decline**

Fig. 7 compares the distribution of hectad records for lesser butterfly-orchid for date classes 1970-1999 and 2000-2011. It has not been re-recorded from several of the 1970-1999 hectads, although it has been recorded from several new hectads. The national survey confirmed that it has disappeared from some areas. It is no longer found at its
only known site in Selkirkshire and has not been recorded in Orkney since the 1990s. It has been lost from sites in Berwickshire and appears to have declined in Argyll, mid-Perthshire, the Cairngorms National Park, Aberdeenshire, Angus and southwest Scotland.

Aims and objectives for 2007-2012
The aims of the SAF project were to stop the decline of the species and to ensure appropriate management of the range of habitats in which it presently occurs.

Types of action identified for the project included:
- Complete the national survey to assess past and present distribution in Scotland.

Aims

Summary of the work undertaken

- A high profile national survey led by SNH, BSBI and Plantlife was launched in 2006 and continued in 2007–12 to gather information on the distribution, ecology and habitat requirements of lesser butterfly-orchid in Scotland.

- Plantlife Flora Guardians and other volunteers were recruited to monitor key sites annually, tracking variation in flowering population sizes and changes in site condition.

- Crofters and owners were identified/contacted during the national survey and several are actively managing sites on their land for orchids.

- Plantlife was commissioned by SNH to carry out a survey to collate information on management regimes on selected sites (Long, 2010).

- Habitat restoration work was implemented by SWT and CRPP to recover declining populations.

- Successful applications were made by landowners/crofters for SRDP funding to secure favourable grazing management at sites in the Outer Hebrides.

- A best-practice management guide was produced by the CRPP (Lavery and Scobie, 2016).

- A final SAF report was written summarising all knowledge gained to date on lesser butterfly-orchid (Lavery, 2012 revised 2016).

Management Action
Management practice

The national distribution survey and the management survey together increased our understanding of the range of habitats for lesser butterfly-orchid and the influence of management upon them. This information formed the basis of advice given in the best-practice management guide (Lavery and Scobie, 2016).

Two main classes of site were found:

• Sites on open hill ground (heathland and moorland) where management input is low or absent. These are usually on the edges of wet flushes or in naturally open areas of vegetation over thin gravelly soils. Grazing is by sheep or deer and may be important in preventing some flushes from becoming overgrown.

• Sites on marginal agricultural land and road verges where grazing and cutting are important management factors. These are usually herb-rich grassland, wet marshy grassland, acid grassland or calcareous heathland.

The surveys identified that the main threats to orchid populations are related to agricultural management. Overgrazing or cutting is a major threat, especially when inappropriately timed, for example during flowering. Conversely undergrazing allows the spread of scrub, the growth of dense grasses and the build up of a thick litter layer. Many sites were relatively wet (wet meadows and wet heath) with lesser butterfly-orchids growing on drier tussocks; here it is important not to change the drainage system, although drainage changes such as new ditching were causing problems at only a few sites.

The site with the largest known population of lesser butterfly-orchid (Flowerfield Meadow) is in the Cairngorms National Park and has been managed in the same way for 60-80 years. This 5 ha site is part of a 16 ha field grazed by 30-40 cattle in summer. Grazing pressure is usually low at the time of flowering as there is better pasture elsewhere in the field. In the past sheep also grazed the field in winter. This level of grazing has kept the vegetation short, under 10 cm, and prevented colonisation by scrub species. Lesser butterfly-orchid, small white-orchid, fragrant-orchid (Gymnadenia borealis) are all present in large numbers. The site is subject to frosts up to mid-June which affect flowering and seed production. The orchids are monitored annually; lesser butterfly-orchid flowering spikes have varied in number from 650 in 2008 to 4,345 in 2013. The numbers of small white-orchid, which is also monitored annually, are exceptional too: they have increased from 101 in 2008 to 1,508 in 2013. These high numbers make this the best site for both species in Scotland.

The habitats at Flowerfield, species-rich upland dry heath, calcareous grassland and upland birch wood, support an unusually rich assemblage of plant species (Scobie, 2016), which in turn make this site one of the most important sites for Lepidoptera (moths and butterflies) in Scotland. Over 180 species of Lepidoptera have been recorded, including seven species listed in the Red Data Book and 20 classified as nationally scarce. Consistent grazing over the past 50 years has produced the outstanding floral diversity and orchid numbers found on this site. The site has no legal protection (it is not an SSSI) and its survival depends on the goodwill of local landowners and the tenant farmer who grazes the site.

Good management can also include cutting for hay. For example a 1.5 ha unimproved croft field in Brora has been managed in the same way for the past 10 years. It is cut in late July or early August for hay. After cutting, about four sheep are immediately put into the field which they graze as part of a larger area, until April. The grass yield is poor but the crofter considers the hay to be very palatable to stock. The sward is species-rich with a high percentage of yellow-rattle (Rhinanthus minor), which reduces grass vigour. Numbers of lesser butterfly-orchid varied from approximately 400 to over 2,000 during the five years of the survey.

A similar small, herb-rich field in Dunbeath (Fig. 8) is ungrazed and cut for hay in July. The number of flowering spikes has varied, with no change in management, from 300 to over 1,000 in the past five years. It has not been fertilised and there is a very high percentage of yellow-rattle in the sward. This site is managed specifically for orchids.

Common themes at these sites are that they are managed in a traditional way, have carefully managed grazing, are often part of a larger grazing unit, and have reduced competition, with more vigorous species suppressed in some cases by abundant yellow-rattle. Timing of grazing and cutting is important in creating optimum conditions for the orchids.

The national survey found that orchid numbers were decreasing at grassland sites without well-managed grazing. Recorders reported declines at under-grazed sites where scrub and tall vegetation shaded out the orchids and a thick litter layer inhibited germination.
As lesser butterfly-orchids occur in a wide range of habitats, no single management prescription can be applied to all sites and site-specific advice needs to be given. The Plantlife report made recommendations to improve conditions for lesser butterfly-orchids at 18 sites based on the individual conditions at each site (Long, 2010). It is possible though to give generic guidance on best management practice for sites that have similar characteristics, summarised below.

**Grazing**

Autumn and winter grazing by cattle is useful in removing excess tussocky growth, and autumn and winter grazing by sheep produces a short even sward. Light grazing during the flowering season or cutting after flowering followed by grazing may be useful at some sites. The management survey recommended supplementary feeding in winter at some sites to extend periods of winter grazing by cattle. Light poaching exposes bare soil and produces germination sites, but care must be taken not to place feeders on orchid areas as heavy poaching can damage underground orchid tubers. Lesser butterfly-orchid was lost from a site in Angus through heavy poaching after cattle were wintered there.

**Water and drainage**

Lesser butterfly-orchid is commonest on the west side of Scotland, where rainfall is highest. In the national survey, it was described as growing in wet conditions at over 70% of all sites. Alteration to drainage patterns may affect the orchids. Drainage maintenance operations can be beneficial by creating disturbed ground for germination. This was the case on a RSPB Reserve on Tiree, but large scale operations can be deleterious. Orchid numbers are thought to have decreased at a Berwickshire site where changes in drainage management lowered the water table and led to the site becoming dryer.

**Annual monitoring by Flora Guardians**

Regular, long-term monitoring is essential to track changes in site condition and evaluate the success of management, though these can be difficult to separate from natural fluctuations. Up to 20 volunteers have undertaken annual monitoring of lesser butterfly-orchid populations, many as part of the Plantlife Flora Guardians scheme. Reports from the scheme show that, since annual monitoring began in 2008, numbers of flowering spikes have fluctuated on nearly all sites monitored, though no pattern or obvious cause is apparent in these fluctuations. This voluntary scheme is the source of most of the information available on long-term population changes for lesser butterfly-orchid.

**Actions to improve sites**

A number of croft fields and gardens are being actively managed for lesser butterfly-orchid through the interest and enthusiasm of the owners/managers. For example, orchid numbers have increased at Latheronwheel from three flowering spikes in 2009 to 117 in 2012, with late cutting and subsequent light grazing by sheep. The numbers of several orchid species including lesser butterfly-orchid are increasing on a croft in Skye since the introduction of a late cutting regime with removal of cuttings.

Populations are recovering on Talich SWT Reserve, from only four flowering spikes in 2006 to 42 in 2012, after scrub clearance and strimming of the sward in autumn with the removal of cuttings followed by grazing. The CRPP helped farmers to restore sites in the Cairngorms National Park by adjusting grazing levels and removing scrub. SRDP contracts have been awarded to manage various sites on Uist, with advice from local SNH staff.
Lessons Learnt, Further Work and Future Recommendations

The choice of lesser butterfly-orchid as a SAF species has raised its profile and increased interest in and action for its conservation. The SAF project established the present status and distribution of lesser butterfly-orchid and provides a sound baseline for future action. SAF has encouraged wider participation in the conservation of this species, including volunteer-based monitoring and management programmes.

Lesser butterfly-orchid is a flagship species for ecologically important sites, such as unimproved species-rich grassland, that are vulnerable and easily lost to changes in management. Positive management action to conserve and enhance conditions for lesser butterfly-orchid will benefit other species, habitats and biodiversity on a landscape scale.

Over 500 sites have been identified in Scotland but conservation action is currently only taking place at a fraction of these. SRDP funding is potentially available (see next section) but it was apparent during the project that the often complex and time-consuming process of applying to the SRDP can discourage land managers from applying for support to benefit this species on small sites. It is recommended that this problem, which applies more widely to species conservation on small sites, should be addressed, perhaps by a simpler small-scale support scheme. More actions could probably be achieved if a similar approach to the project for the marsh fritillary and other SAF Lepidoptera species could be taken, with a dedicated project officer working more widely across the orchid’s core range to advise site managers and their agents on appropriate prescriptions for management.

Future action

Practical advice on best management, tailored to individual lesser butterfly-orchid sites, should be made available to landowners and managers, together with population data from the national survey. The new management guide (Lavery and Scobie, 2016) provides a good basis for such advice, which might include links to associated species such as devil’s-bit scabious and marsh fritillary butterfly. Funding may be available through the Rural Priorities mechanism of SRDP 2014-2020, which has a ‘Supporting Biodiversity’ package with guidance on options to benefit UKBAP and SAF species including lesser butterfly-orchid. Appropriate options such as Management of species-rich grassland, Management of wetland or Management of habitat mosaics would need to be selected carefully according to the nature of a site.

It is of concern that over 90% of the sites identified during this project have no legal protection, as factors such as their small extent and marginal situation often make them vulnerable to land use/management change. For example three important sites are known to have come under threat from change in management since the end of the SAF project in 2012. While SSSI notification cannot be a ‘panacea’ for such a widely dispersed species, it would seem wise to safeguard the most exceptional populations through appropriate application of the SSSI selection guidelines. At many undesignated sites the presence of lesser butterfly-orchid is associated with habitats of high conservation value, and such sites could alternatively be considered as ‘local nature conservation sites’ to alert landowners, site managers and public authorities to their importance.

The project has engendered a great deal of interest and enthusiasm across Scotland for conservation of this charismatic species. It will be important to harness this to try and reverse the orchid’s historic decline.

Further Information

Key Management Messages

Analysis of site information collected during the SAF project suggests that the following steps should be taken to achieve successful management for lesser butterfly-orchid:

• **Identify and disseminate the location and full extent of orchid populations** and the habitats and vegetation in which they occur. This will help to target effective management to the right areas or fields.

• **Many sites are unimproved** and being managed in a traditional way without the addition of fertilisers. This should be encouraged and supported through appropriate funding schemes.

• **Protect sites from agricultural improvement** (including drainage of wet areas and applications of fertiliser, herbicide, lime, slurry and farmyard manure) and woodland regeneration schemes which cause unfavourable changes to the habitat of the orchid.

• **Orchids and other herb species benefit from a short open sward** of 10 cm or less.

• **Establish and maintain a well-timed grazing and/or cutting regime** permitting orchids to grow, flower and set seed whilst removing the annual growth of vegetation to maintain a favourable open sward and prevent litter build-up. An example of a grazing regime for the orchid might be very light or no grazing during the period from mid-May until mid-August, light to moderate grazing during the period mid-August until end of August followed by periods of moderate or occasionally heavy grazing between September and mid-May.

• **Monitor the site and orchid population**, adapt the grazing or cutting regime where fine-tuning of sward conditions is required and manage orchid areas to keep them free of bracken and scrub.

• **Avoid overwintering large numbers of livestock on small or wet sites** where this may lead to excessive poaching. Where supplementary feeding is required to extend periods of grazing through autumn and winter, site feeding stations well away from orchid areas.

• **If the lesser butterfly-orchid is already present at a site in high numbers** then it is likely that the existing management regime is already favourable. In these situations, the best possible course of action is to ensure that this pattern of management is continued in the long-term.

References


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The SAF Partners

- Scottish Natural Heritage
- Cairngorms National Park Authority
- Botanical Society of the British Isles
- Plantlife
- Scottish Wildlife Trust
Small Cow-wheat

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Summary

- **Small cow-wheat** is a nationally scarce annual – the UK distribution consists of only 19 sites, mostly in Scotland, and only five populations have more than 500 individuals.

- **Habitat consists of fragmented upland deciduous woodland** – sites are typically cool and wet, close to water bodies and have an open canopy.

- **The Species Action Framework (SAF) project sought to address population status and reinstate interactions with wood ants** – the overall aim was to increase the number and size of Scottish small cow-wheat populations, and improve seed dispersal by wood ants.

- **Population expansion trials have shown initial success** – attempts to create entirely new populations are not so encouraging.

- **Cultivation trials** – protocols for the successful cultivation of small cow-wheat have been developed to allow seed to be grown for future restoration work.

- **Wood ants** – despite careful searching in several areas of Highland Scotland, only one site has been found that supports wood ants and small cow-wheat.

- **Habitat management** – this is now being attempted in order to increase the quality and extent of small cow-wheat habitat. This approach is recommended as the first course of action in the protection of all small cow-wheat populations.

- **Detailed monitoring guidance has been developed** – this should be used to monitor the status of small cow-wheat populations and the effectiveness of attempted management.

Introduction

**Species background**

Small cow-wheat (*Melampyrum sylvaticum*) is a hemi-parasitic annual herb with bright yellow, nodding flowers in pairs up the main stem and side branches (Fig. 1). It is found in remnants of upland broadleaved woodland where birches (*Betula* spp.) are typically the dominant tree species.

**Why was this species on the SAF list?**

This species met criterion 1a of the SAF, as a species for conservation action, because it had declined substantially in the UK, and Scotland is now a stronghold. Recent research had improved our understanding of the species so that targeted actions could be undertaken to instigate recovery. These actions could also benefit other species such as insects in the same habitat. Small cow-wheat was listed as a UK Biodiversity Action Plan Priority Species and is included on the Scottish Biodiversity List.

**Habitat and distribution**

Once widespread in Britain and Ireland (c. 110 sites; Rich et al., 1998) small cow-wheat is now restricted to only 19 sites, mostly in Scotland north of the Highland Boundary Fault. Of these, only five sites support more than 500 plants and seven sites support populations of 100 individuals or fewer.
These small populations typically persist in isolated remnants or small fragments of upland woodland along river gullies, in steep-sided ravines or high up on rock ledges. At lower altitudes this species occupies high humidity sites - close to water, north-facing and under a closed canopy. At higher altitudes the climate is cool enough to maintain adequate moisture levels without a dense canopy, although the shorter growing season constrains plant size (Dalrymple, 2007).

Extant sites have all been undisturbed for more than a century, indicating that the species has a requirement for stable conditions. However, many sites are experiencing incremental habitat deterioration resulting in decreasing densities of plants even where the extent of habitat has remained roughly the same over centuries. The small size of the remaining populations puts them at risk of extinction from random population fluctuations and one-off events such as flooding, landslips or human damage.

**General ecology**

Small cow-wheat is a hemiparasite and therefore gains additional water, nutrients and organic compounds from the roots of host plants. Research has demonstrated that small cow-wheat plants attempt to attach to the roots of a range of species including blaeberry (*Vaccinium myrtillus*), various grasses, and herbs such as devil’s bit scabious (*Succisa pratensis*). However, cultivation trials have shown that many of these species cannot support small cow-wheat plants. Good hosts are birch, rowan and various vetches.

This ‘summer annual’ flowers from June to early August and sets seed from late July to early September. The seeds are exceptionally large for an annual and are adapted for dispersal by wood ants as they have a small body on them called an elaiosome (Fig. 2), rich in fat and protein, which provides a reward for ants that carry the seeds back to their nests. The ants remove the elaiosomes, then take the seeds from the nest and deposit them intact as refuse. It has been hypothesised that this relationship with ants is important for the dispersal of seed to favourable microsites for germination and establishment, such as gaps in the forest canopy where ants build their nests. However, this mechanism appears not to be operating at remaining sites for small cow-wheat in Scotland because of the local absence of wood ants. As a consequence, seed dispersal is severely limited.

Recent genetic research has demonstrated that most Scottish small cow-wheat populations are highly inbreeding, exhibit very low levels of genetic diversity and are highly differentiated from one another (Crichton, 2012). A potential consequence of inbreeding and isolation from gene flow is that remaining populations can become highly adapted to the particular site conditions where they occur. This ‘local adaptation’ (if it is occurring) combined with low levels of genetic diversity may severely limit the potential of these small, isolated populations to adapt to future climate change.

A full description of the ecology of small cow-wheat can be found in Dalrymple (2007). Scottish sites that support small cow-wheat can be summarised as follows:

- Often in principally deciduous upland woodland communities (National Vegetation Classification W11 or W17) or in some cases, the community is similar in composition to the understory vegetation of these communities but tree canopy is absent.
- Tree canopy cover (or shading created by local topography) of > 30% and showing a negative correlation between canopy cover and altitude, i.e. with increasing elevation, the coverage from a tree canopy reduces.
- A broadly northerly aspect.
- Distance to water bodies (lochs, rivers or streams) usually < 20 m.
- Altitude of 110–640 m above sea level.
- According to the Forestry Commission’s Ecological Site Classification system, an accumulated day-degrees > 5°C (AT5) within the range of 441–1207, and a moisture deficit within the range of 0-106 (White et al., 2000).
Aims

Aims for 2007-2012

The main aims were to:

- Enlarge existing small and isolated populations.
- Reintroduce wood ants to mobilise seed at remaining sites.
- Establish new populations with high genetic diversity in surviving wood ant areas.
- Establish new populations of small cow-wheat with high genetic diversity and wood ants in newly established pine or birch woods.

Additionally, the aims of a PhD research project which ran concurrently with the SAF project were:

- Understand the diversity and distribution of genetic and phenotypic diversity of the species.
- Develop horticultural protocols to enable conservation translocations and ex situ collections to be carried out with greater rates of success.

Management Action

Summary of the main actions carried out

- Local population expansion trials were carried out in 2010 at Glen Tilt by the Cairngorms Rare Plants Project as a pilot for wider implementation at other sites. Following signs of initial success, this was followed up with additional plots at Glen Tilt and similar work is now underway at a further two sites – the Birks of Aberfeldy and Keltneyburn.

- Cultivation techniques were developed for small cow-wheat creating an ‘insurance’ ex situ collection, and producing seed for restoration work.

- Creation of new populations in unoccupied but potentially suitable habitat was implemented in 2005 by the University of Aberdeen and Forest Research and continued throughout the SAF period with mixed success.

- Genetics research was undertaken at the Royal Botanic Garden Edinburgh (RBGE) and University of Aberdeen in 2008-2012 to study

History of decline, contributory factors and current threats

A key cause of the historical decline of small cow-wheat has been the loss and fragmentation of its woodland habitats due to extensive felling of woods for timber, conversion of woodland to agricultural land, and unrestricted heavy grazing of upland habitats by deer and domestic livestock. In addition to the direct loss of woodland habitat, unfavourable management, such as overgrazing, fencing to exclude grazing animals, planting of dense conifer stands, and fertiliser run-off from nearby farmland, has further degraded the habitat quality of remaining sites where this species occurs.

The small size, isolation, low levels of genetic diversity and lack of dispersal capacity leaves the remaining populations of small cow-wheat highly vulnerable to extinction. The breakdown of the mutually beneficial relationship as a result of the loss of wood ants reveals the parallel loss of species composition that is evidently occurring in the isolated and degraded fragments or ‘refuges’ where there the populations remain.

This species shows a requirement for cool, humid sites in the UK, and is likely to be susceptible to climate change. It is conceivable that gradual warming of the climate since the end of the last glacial period has contributed to the current restricted distribution of this species. Predicted future climate change almost certainly poses a threat to the long-term survival of this boreal-montane species in Britain.
the effects of fragmentation on genetic diversity and inform future conservation work on this species.

- **The feasibility of introducing small cow-wheat to sites supporting wood ants** was explored but the habitat requirements of each species were found to be too different to warrant further action, with the exception of one site.

- **Habitat management** including small-scale targeted actions, such as bracken and canopy management, and larger-scale actions, such as woodland restoration, has been implemented or is currently being taken forward as part of long-term management plans at five key sites for this plant.

**Local population expansion**

The aim of local population expansion work is to increase the extent of small cow-wheat populations, thereby reducing the risk from localised threats such as brash dumping following forestry activities, landslides and vehicle damage, all of which have reduced the size of Scottish small cow-wheat populations in the last decade. At sites where the number of plants is large, seed production is plentiful and dispersal limitation is evident, there is clearly a case to intervene and assist the plant to reach nearby areas of suitable habitat. The following sections describe a trial to establish small cow-wheat in areas of suitable unoccupied habitat in close proximity to an existing population in Glen Tilt. This population achieves the highest densities of any Scottish small cow-wheat population and therefore made an ideal candidate for local population expansion.

**Location of work**

One of the largest small cow-wheat populations in Scotland occupies a site on the east side of the River Tilt (NN8869). Although the extent of the population is limited by the valley side to the west and a track to the east, there is potentially suitable unoccupied habitat immediately to the south and across the track to the east.

**Methods**

Five planting plots of 2 x 2 m were established in carefully selected areas of habitat to the east and south of the natural population (Fig. 3) and marked at the corners with wooden pegs to permit future monitoring. Seeds were collected from the natural population on 26 September 2010 and sown into the five plots the following day. 300 seeds were planted in each plot by scattering them over the entire area. Plots were monitored in 2011 and 2012 when counts were made of small cow-wheat plants inside and around the plots. Plants were also assigned to two health classes, and the relative proportions in each class recorded: (i) large plants (15-25 cm tall) with regular branching and many flowers = healthy, (ii) small plants (<10 cm) with no side branches and few or no flowers = poor.

**Results**

Small cow-wheat plants were recorded in all five planting plots in 2011 and 2012. However, there was considerable variation in the number of plants per plot and the relative proportions of plants in each health class (Table 1). Plot 1 was least successful with 95 plants in 2011 and only three plants in 2012. This plot was situated at the upper edge of the woodland, furthest away from the river, and had a much higher cover of tall grasses compared to the other plots. In the four remaining plots, the number of plants increased between 2011 and 2012. Plots 3, 4 and 5 contained between 192 and 425 in 2012 and the vast majority of them were classed as healthy. Some unexpected movement of seeds had taken place since planting in 2010. Groups of plants had established outside plots 3, 4 and 5 (but within only 1–2 m of them) suggesting that some very local dispersal of seed had taken place.
Following the initial success in plots 3 to 5, three additional plots of 5 x 2 m were created to reinforce these areas (Fig. 3) and similar work commenced at the Birks of Aberfeldy and Keltneyburn in 2012. Three plots have been planted at Birks of Aberfeldy, and there are plans for further expansion. At Keltneyburn the small cow-wheat population is very small (<50 plants), so a small number of seeds were collected in 2012, to be germinated and grown at the RBGE with the intention of producing more seed for planting in unoccupied habitat near the existing population (see following section).

Cultivation protocols

Owing to the rarity of small cow-wheat, and the vulnerable state of remaining populations, cultivation protocols have been developed to produce seed for experimental work at the RBGE and the Cruickshank Botanic Garden, Aberdeen. More recently, seed has been ‘bulked-up’ for local expansion work i.e. seed was grown in favourable ex situ conditions where release from competition and herbivory produces greater seed yields than in the wild. An ex situ collection of small cow-wheat is now maintained at the RBGE. The following is a brief summary of the protocols reported by Crichton et al. (2012) and findings of research projects conducted at the University of Aberdeen.

Recommended method of cultivation

Seeds can be collected from wild plants or those in cultivation as soon as the seed pods have split, usually from late July. Seed should be transferred quickly and stored in cold (4-6°C), moist, breathable conditions where viability can last for three months, and potentially longer (although this has not been tested).

Table 1. Monitoring data for small cow-wheat population expansion plots established at Glen Tilt in 2010.

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>No. seeds sown</th>
<th>Vegetation description</th>
<th>SCW plants 2011¹</th>
<th>Plant health 2011</th>
<th>SCW plants 2012²</th>
<th>Plant health 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300</td>
<td>Height: 30-50 cm Graminoids: 80-85% Forbs: 10% Open/mossy: 5%</td>
<td>95 [31.5%]</td>
<td>25% 15-25 cm tall, regular branching, many pairs of flowers. 75% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
<td>3 [497%]</td>
<td>All plants &lt;10 cm tall, no branching, few or no flowers.</td>
</tr>
<tr>
<td>2</td>
<td>300</td>
<td>Height: 20-40 cm Graminoids: 50-60% Forbs: 20-25% Open/mossy: 20-25%</td>
<td>98 [32.5%]</td>
<td>65% 15-25 cm tall, regular branching, many pairs of flowers. 35% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
<td>129 [41.5%]</td>
<td>50% 15-25 cm tall, regular branching, many pairs of flowers. 50% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>Height: 15-35 cm Graminoids: 20-25% Forbs: 35-40% Open/mossy: 35-40%</td>
<td>253 [84%]</td>
<td>80% 15-25 cm tall, regular branching, many pairs of flowers. 20% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
<td>425 [68%]</td>
<td>85% 15-25 cm tall, regular branching, many pairs of flowers. 15% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>Height: 15-35 cm Graminoids: 10-15% Forbs: 30-35% Open/mossy: 40-50%</td>
<td>124 [41%]</td>
<td>90% 15-25 cm tall, regular branching, many pairs of flowers. 10% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
<td>192 [55%]</td>
<td>90% 15-25 cm tall, regular branching, many pairs of flowers. 10% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
</tr>
<tr>
<td>5</td>
<td>300</td>
<td>Height: 20-40 cm Graminoids: 10-15% Forbs: 50-60% Open/mossy: 30-35%</td>
<td>229 [76%]</td>
<td>90% 15-25 cm tall, regular branching, many pairs of flowers. 10% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
<td>315 [37.5%]</td>
<td>90% 15-25 cm tall, regular branching, many pairs of flowers. 10% of plants &lt;10 cm tall, no branching, few or no flowers.</td>
</tr>
</tbody>
</table>

Values given in [] are ¹the % of seeds planted per plot in 2010 which had established as plants in 2011, and ²the % change between the number of plants per plot in 2012 compared to the number in 2011. Monitoring was conducted on 22/06/2011 and 26/07/2012.
Seeds break their winter dormancy through prolonged exposure to cold temperatures, including temperatures below freezing. Preferentially sowing seeds that have undergone the first germination by producing a radicle (the emerging root) leads to higher establishment success. Seeds that do not produce a radicle may simply be dormant. Cultivation conditions must meet both the over-wintering requirements of the seed, and the growing season requirements of the plant. During the growing season plants require cool, humid, shaded environments with moist but free-draining soils. This has been achieved by sowing small cow-wheat in pots filled with a mix of compost and sand, using shade fabric and careful watering. As small cow-wheat is hemiparasitic, the roots of a suitable host plant must be near to the seedling to allow parasitism. Host plants successfully used in cultivation include legumes such as tufted- and bush vetch, and saplings of downy birch and rowan. Small cow-wheat is able to set seed without the need for cross-pollination. If seed is to be used for planting back into wild populations, it is important to ensure the pure provenance of the seed by preventing cross-pollination between plants of different populations using net fabric ‘cloches’.

**Results**

Germination of small cow-wheat in cultivation is usually around 40% of the seeds sown (Crichton et al., 2012). This figure is similar to that reported from wild populations but with the benefit that post-germination survival is much improved in cultivation.

**Creation of new populations**

An attempt to create new populations of small cow-wheat in the Forest Habitat Network in highland Perthshire was initiated in 2005. The aim was to investigate how small cow-wheat survival was affected by i) the identity of the populations from which seed was collected, and ii) the habitat at the sites receiving seeds. The trial was intended to inform any future attempts to create populations on a bigger scale.

**Methods**

Small cow-wheat seeds were moved to six sites within the extent of its former Scottish range. Seeds were translocated in three phases (2005, 2006 and 2008) to different combinations of the six receptor sites. Each phase of translocation used increasing numbers of seed: approximately 100 seeds per site in 2005, 360 seeds in 2006 and 500 seeds in 2008. The trial used an adaptive management approach in that sites that showed promising survival in phases 1 and 2 received additional seed inputs in phase 3.

**Results**

Findings suggest that future seed translocation should be to sites that are ecologically similar to the donor population and into sites that fall into the cooler and wetter range of environmental conditions currently supporting Scottish populations of small cow-wheat (for a full report see Dalrymple and Broome, 2010).

A follow-up project undertaken in 2010 compared the sites used in the original translocation work with four natural populations in terms of climate data, soil nutrient content, slope, distance to the nearest water body and canopy cover. The latter two variables were more influential than climatic factors in explaining the success of attempts to create small cow-wheat populations. Sites that had been selected for the creation of new populations but had failed to support small cow-wheat were associated with greater distances from rivers or streams and had higher canopy cover.

**Introduction of small cow-wheat to sites supporting wood ants**

In 2008 and 2009 several sites in the Glen Affric area known to support wood ant nests were investigated for their potential to provide suitable habitat for small cow-wheat. Most sites were dismissed because the canopy was too open and the ground flora was unsuitable. Red Burn at Dundreggan Estate was selected as a small cow-wheat introduction site because wood ants were present, the site was close to a waterfall and deciduous woodland was being regenerated in the area. Four hundred seeds were moved from a nearby population in Glen Affric growing in very similar conditions in 2009. The following year, 77 plants had germinated and 69 of these were flowering. This project was part of the Trees for Life ground flora restoration programme and further monitoring was undertaken by them.

Extensive searching for sites supporting wood ants that might also support small cow-wheat was conducted in the Cairngorms National Park, a remaining stronghold for wood ants. Unfortunately,
these searches were without success because of two key factors: (i) the extent of broadleaved woodland suitable for small cow-wheat is very limited within the Park, and (ii) wood ants mainly occur in pinewoods unsuitable for small cow-wheat.

**Habitat management recommendations**

Generic site management must aim to maintain the conditions that support healthy small cow-wheat populations (see General Ecology section above). Some management interventions are described below:

- Prevent the encroachment of invasive species such as bracken and rhododendron, both of which will shade out small cow-wheat and are unlikely to be suitable host plants.
- Prevent heavy grazing such as that caused by enclosed livestock; but see following point.
- Avoid the understory community developing into ‘rank’ vegetation by allowing some grazing such as that resulting from sustainable unenclosed deer herds and healthy populations of small mammal herbivores.
- Prevent the abstraction of water from water bodies proximal to small cow-wheat populations where this will have a detrimental effect on ambient humidity levels.
- Restore and extend the extent of suitable broadleaved woodland habitat through regeneration or planting at, or close to, sites where this species remains.
- Maintain or improve the status of wood ant colonies (genus *Formica*) that may contribute to small-scale seed dispersal.

Habitat management has not been attempted with the exception of sites on Atholl Estate, Perthshire, where there is a small but growing small cow-wheat population. Bracken swiping commenced in the summer of 2012. Tree guards were put on 20 naturally occurring tree seedlings in October 2012 to protect them from sheep and deer browsing.

**Lessons Learnt, Further Work and Future Recommendations**

We make seven points to help with further work:

- **Local population expansion is a feasible option for increasing population extent** – assuming that suitable habitat is available nearby, moving seed from populations which are dispersal-limited is a realistic option for maintaining or enhancing numbers of plants.
- **Ex situ cultivation can be used to bulk-up seed with easily available horticultural equipment** – if seeds from multiple sources are to be cultivated and returned to wild populations, care should be taken to record the identity of the parent populations and isolate them from pollen exchange.
- **Creation of new populations has been largely unsuccessful** – only two of six sites continue to support small cow-wheat plants in very small numbers.
- **The species is highly inbreeding,** and most Scottish populations exhibit very low levels of genetic diversity and are genetically and morphologically differentiated from one another.
- **Avoiding further reductions in the number and size of existing small cow-wheat populations is imperative** to conserve remaining genetic diversity.
- **Local adaptation may be a potential constraint** on the success of translocations of small cow-wheat to new sites – donor and receptor sites should be carefully matched to increase chances of success.
- **Wood ant habitat and small cow-wheat habitat rarely coincide** and where habitat requirements for both species are met, it is uncertain as to whether wood ants can effectively disperse small cow-wheat seeds.

To support the continued survival, and ideally expansion, of small cow-wheat, we recommend that favourable woodland habitat be maintained, restored and expanded where possible. Local population expansion can be effective in carefully selected circumstances but the creation of new populations has not, so far, proved to be a successful strategy for the recovery of small
cow-wheat in Scotland. Guidelines for monitoring small cow-wheat populations can be found in Dalrymple (2015).

**New and ongoing work since SAF ended**

Work on small cow-wheat since the completion of SAF has focused on monitoring of attempts at population expansion through small-scale movement of seeds and the further cultivation of plants. The RBGE is now the lead partner in small cow-wheat conservation.

### Further Information

- [http://cairngormsrareplants.org.uk/](http://cairngormsrareplants.org.uk/) – Cairngorms Rare Plant Project website, with information on ecology and distribution and an identification guide.

### References


### Key Management Messages

- Maintain suitable habitat supporting extant populations, including through control of invasive species, maintenance of favourable grazing regimes and prevention of the canopy becoming closed.
- Local population expansion may prove to be a useful method for improving the resilience of populations to small-scale threats such as landslides, vehicular damage and trampling.
- Collections of the species are maintained at the RBGE and will be important in generating seed for experimental work and possible translocations in the future.
Acknowledgements

Much of the work described above was supported by SNH SAF project funding and guided by the Melampyrum sylvaticum Species Action Plan National Steering Group including Chris Sydes, Paul Gallagher and Alice Broome. Thanks to the students of the University of Aberdeen whose research contributed to this management guidance: Susan Rodgers, Yvonne Mclean, Robert McAskill and Fiona Beaton. Thanks also to the landowners and managers that have allowed access to their land for fieldwork, and for their long-standing support and participation in recovery work for small cow-wheat, especially Alastair Godfrey and Jeannie Skoyles of the Perth and Kinross Ranger Service, Shaila Rao and Willie Fraser of the National Trust for Scotland, Donald Rowantree and staff of the Corrour Estate, Polly Freeman at Atholl Estate and Adam Powell formerly of Trees For Life. Dr Tim Rich kindly provided comments as external reviewer.

The SAF Partners

- Scottish Natural Heritage
- Scottish Wildlife Trust
- Forest Research
- University of Aberdeen
- Cairngorms Rare Plants Project
- Royal Botanic Garden Edinburgh

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Woolly Willow

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Summary

- Woolly willow is a montane species that is vulnerable in Scotland because most of its few remaining populations are small and threatened with the further loss of individuals. It was listed as a Priority species under the UK Biodiversity Action Plan (UKBAP), and is included on the Scottish Biodiversity List. It is also a component of subarctic willow scrub, a habitat type listed on Annex I of the EC Habitats Directive.

- The species is confined to 13 sites in Scotland, of which three are functionally extinct and three are at risk. Several of the remaining seven sites require reinforcement.

- It is now a plant restricted to wet basic rocks and similar areas with late snow-lie with a northerly aspect at altitudes of 620–1,036 m. It is vulnerable to grazing and is becoming increasingly threatened by reduced snow-lie.

- Techniques for recovery involve reducing grazing by fencing or deer/sheep control, and the planting of container-grown willows sourced from local seed or cuttings. Plants are put out in summer at the end of their second or third growing season.

- A total of 1,587 woolly willows have been used to reinforce the populations at three sites and create two new sites. Care was taken to maximise genetic variation in the planted stock by using material from 30 parent plants where possible.

- Good plant hygiene must be used during the taking of cuttings and during propagation and planting to avoid the introduction of novel pests, especially fungal infections.

- A rationale for any planting should be formulated and a standardised monitoring programme devised so that lessons may be learned. Consideration should be given to the avoidance of compromising other habitats and so threatening other scarce species.

Fig 1. Location of known sites for woolly willow in Scotland, with estimated numbers of plants in 2007 (see Table 1).

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• Formal monitoring should take place after two to three years and then at approximately five year intervals, but qualitative monitoring should be annual to diagnose problems. Subsequent plantings should be a reinforcement of successful establishment and growth rather than a repeated attempt to plant in an area that is apparently unsuitable.

**Introduction**

Woolly willow (*Salix lapponum*) is a vulnerable montane willow confined in the UK to 13 sites in Scotland (Marriott in Wigginton, 1999; Fig. 1 and Table 1). It is a plant found on wet, basic rocks at altitudes of 620–1,036 m. All sites have a northerly aspect. Its rarity in Scotland is a reflection of the scarcity of basic rocks at high altitude and its vulnerability to grazing. Hence the sites where it occurs are inaccessible and rocky, and/ or are areas with late snow-ife. Late snow-ife may protect the willows from frost and wind damage,

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Grid reference</th>
<th>Designation</th>
<th>Estate numbers at 2007</th>
<th>Surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ben Lawers</td>
<td>NN 653 442</td>
<td>Ben Lawers NNR, SSSI, SAC</td>
<td>1</td>
<td>Marriott, 1994, Crook, 2000</td>
</tr>
<tr>
<td>2. Meall nan Tarmachan</td>
<td>NN 578 389</td>
<td>Ben Lawers NNR, SSSI, SAC</td>
<td>1</td>
<td>Marriott, 1994</td>
</tr>
<tr>
<td>Crag 2</td>
<td>NN 483 337</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>6. Glen Callater</td>
<td>NO 20 80</td>
<td>Cairngorms NNR, SSSI, SAC</td>
<td>123</td>
<td>Part surveyed Crook, 2000, resurveyed Marriott, 2006</td>
</tr>
<tr>
<td>NO 20 79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Caenlochan:</td>
<td>NO 173 767</td>
<td>Cairngorms NNR, SSSI, SAC</td>
<td>4</td>
<td>Surveyed 2005, needs resurvey</td>
</tr>
<tr>
<td>Craigie Doubs</td>
<td></td>
<td></td>
<td>6</td>
<td>Surveyed 2000, 2008</td>
</tr>
<tr>
<td>Monega Hill</td>
<td>NO 186 757</td>
<td></td>
<td>28</td>
<td>Resurveyed 2011</td>
</tr>
<tr>
<td>Little Glas Maol</td>
<td>NO 18 76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coire Sharroch</td>
<td>NO 247 748</td>
<td></td>
<td>2</td>
<td>Needs resurvey</td>
</tr>
<tr>
<td>Coire Fee</td>
<td>NO 267 741</td>
<td></td>
<td>2</td>
<td>Needs resurvey</td>
</tr>
<tr>
<td>Coire Kilbo</td>
<td>NO 242 764</td>
<td></td>
<td>4</td>
<td>Needs resurvey</td>
</tr>
<tr>
<td>Craig Maud</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Tigh Mor na Seilge</td>
<td>NH 133 163</td>
<td>none</td>
<td>106</td>
<td>Marriott, 1994, Crook, 2000</td>
</tr>
<tr>
<td>11. Sgurr nan Conbhairean</td>
<td>NH 136 137</td>
<td>none</td>
<td>91</td>
<td>Marriott, 1994</td>
</tr>
<tr>
<td>12. Carn Ghlusaid</td>
<td>NH 145 127</td>
<td>none</td>
<td>57</td>
<td>Surveyed 2004</td>
</tr>
<tr>
<td>(Coire Cheap)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1. The 13 woolly willow sites in Scotland.**
as well as grazing. It is classed as ‘Vulnerable’ in the Red Data List for Great Britain (Cheffings and Farrell, 2005) because most of its few remaining populations are small and threatened with the further loss of individuals, though it is not threatened in Europe. It was identified as a UKBAP Priority species and is included on the Scottish Biodiversity List. It is a component of subarctic willow scrub, which is a habitat type listed on Annex I of the EU Habitats Directive.

It is a dioecious species (male and female catkins occur on separate plants) and so three ‘populations’ of single plants are functionally extinct (Table 2). It is likely that the separate sexes need to be well within an estimated 50 m of each other for effective pollination by flies and bumblebees (Mardon, 2000). It is also likely that bumblebees are the more effective pollinators over longer distances.

It has been suggested (Marriott in Gilbert et al., 1997) that the requirements to maintain a viable population of a montane willow are:

1. Male and female plants well within an estimated maximum 50 m of each other for effective pollination.
2. Bare ground for seedling establishment.
3. Appropriate (low) levels of grazing.
4. Snow cover that protects plants from frost damage and grazing during the winter and late spring.
5. Relatively cool/damp soil conditions.
6. A minimum number of plants to produce sufficient ‘seed rain’ to colonise bare ground at rates equal to the loss of mature plants.

In May 1999 the Woolly Willow Steering Group (WWSG) was constituted to implement a Woolly Willow Species Action Plan. The lead partner was the National Trust for Scotland (NTS). Among the first tasks that were tackled was an attempt to complete the survey of the woolly willow sites started by Marriott (1994) and also to identify what constituted a ‘viable’ population. With respect to the latter, the habitat requirements that would support a viable population (see above) were broadly accepted with the qualification that the soils should be base-rich, the altitude over 600 m, and the vegetation characterised by National Vegetation Classification types W20, U17 and CG12 (Averis et al., 2004). It was suggested that a viable population would also require a minimum of 50 plants with approximately equal numbers of males and females. It had taken much of the intervening time between 1999 and 2007 to arrive at reasonably accurate counts for the different populations.

A total of 1,838 plants were estimated to be present in 2007. Of the 13 sites for woolly willow (Table 1) seven could initially be classified as apparently viable, three as at risk and three as functionally extinct (Table 2). However, when the sites were looked at in more detail, some of the larger colonies were found to consist of very small sub-colonies separated by more than 50 m from their neighbours and were, therefore, in need of reinforcement.

The original UKBAP Species Action Plan objectives were therefore modified and made more realistic in the light of experience, and adopted as the targets for the Species Action Framework (SAF) project (Sydes, 2008). Fortunately by the start of the SAF project there had also been some important research work on montane willows carried out in 2002-05 (Scottish Montane Willow Research Group, 2005). This helped inform the project, especially with reference to the genetic variability of the different populations.

Table 2. An assessment of the viability of the woolly willow populations.

<table>
<thead>
<tr>
<th>Apparently viable</th>
<th>At risk</th>
<th>Functionally extinct</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Sgurr nan Conbhairean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Carn Ghluaidh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Geal Charn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 sites</td>
<td>3 sites</td>
<td>3 sites</td>
</tr>
</tbody>
</table>
Aims

Aims and objectives for 2007-2012

Three objectives/targets were set for the SAF woolly willow project:

- To increase total population size to over 2000 plants by 2010.
- To ensure that populations are stable or increasing at all known sites by 2015.
- To increase the range of the species by ensuring that populations at four sites can expand by 2015.

Management Action

Summary of the main actions carried out

The SAF project included work in four main areas:

- Seeds and cuttings were collected from plants in Coire Sharroch, Caenlochan, Coire Kander, Glen Callater and Meall na Samhna.
- Seeds and cuttings were grown at Royal Botanic Garden Edinburgh (RBGE) and Stonehaven (first author’s garden) and then pricked out into root trainers. Plants for Ben Lawers National Nature Reserve (NNR) and Meall na Samhna were grown at the NTS nursery in Killin.
- A total of 1,587 woolly willows were planted at five sites (Table 3).
- Monitoring of the planted willows was carried out at Glas Tulaichean and Coire Garbhlich.

Propagation and Planting

By 2007 it was already known that it was possible to propagate montane willows in large numbers, as had been done in the pioneering work by NTS staff at Ben Lawers (Mardon, 2000, 2003). However, achieving population growth at any site required that the factors preventing regeneration were also being addressed. The exclosure at Coire Sharroch, erected in 1991, had shown that fencing on its own would not necessarily facilitate population expansion. So reinforcement was planned at this site to provide an opportunity to test the hypothesis that woolly willows would grow successfully if planted in areas of late snow-lie with reduced grazing in late winter and spring.

Fortunately by 2007 deer numbers were being significantly reduced on Glen Feshie estate, thus making Coire Garbhlich a candidate site. A reduction in the numbers of deer was also about to happen at Caenlochan. There was a very large exclosure at Creag an Lochain (Meall nan Tarmachan), erected in 2000, and there were already exclosures at Ben Lawers (Mardon, 2003) and Coire Sharroch. Planting had already been carried out at Glas Tulaichean in 1999 (Phil Lusby, pers. comm.). Much later, sheep were removed from Meall na Samhna making reinforcement possible there too, in 2012.

The target for planting at any site was to grow seed from at least 30 parent plants. Sometimes cuttings were taken if there were not enough parent plants producing seed. No seeds were seen or were accessible in 2008 in Coire Garbhlich although some cuttings were taken.

The aim was also not to over-represent one parent amongst the progeny. For traceability the seed parents (for plants grown at RBGE) were photographed, a GPS reading recorded and a leaf taken and put in silica gel to allow future tracing by DNA analysis.

The SAF project funding enabled the shade tunnel (Fig. 2) and other resources to be purchased for RBGE and supported the purchase of materials for the NTS nursery at Killin (Fig. 3); this greatly increased the output (Table 3).
Planting was carried out during the summer months. At Coire Sharroch this was always in August when the plants had finished growth for the year. Fertilizer was not used for the month or so before planting out so that they were not too lush, in case this made them more vulnerable to grazing by voles or slugs. Plants were thus put out at the end of their second season’s growth (13-14 months after the seed was collected). They were sometimes kept for an extra season before planting out. These plants were sturdier and possibly had a better chance of survival but there was the greater risk of them picking up rust disease or being attacked by vine weevil while at RBGE.

A day or two before planting, the willows were removed from their root trainers and wrapped in bundles of six with cling film (the cling film roll was cut in half). This made it easier to transport them up the hill in planting bags while wearing harnesses. Using the harnesses made planting on steep ground much easier. At Coire Sharroch and Coire Garbhlagh each bundle of plants was of carefully mixed parentage. Planting dibbers, trowels and a tool that cut a plug sized slot were all used for planting. Planting was done by volunteers and staff from SNH, NTS and RBGE (Fig. 4).

At Coire Sharroch the sites to be planted were marked a few days beforehand using forestry flags and the volunteers then planted six or twelve plants around each flag as instructed. At Coire Garbhlagh planting was mostly done by two climbers employed from Glenmore Lodge because of the difficulty of the terrain. They were directed by walkie-talkie and the area they planted was marked by forestry flags so that the planting areas could be photographed from a vantage point across the corrie. An account of the 2009 plantings at Coire Sharroch is given in Fleming (2009) and at Coire Garbhlagh in Moore (2009).

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1b. Lairig Innein (new)</td>
<td>34</td>
<td>9</td>
<td>10</td>
<td>71</td>
<td></td>
<td></td>
<td>124</td>
</tr>
<tr>
<td>2b. Creag an Lochain (new)</td>
<td>60</td>
<td>66</td>
<td>135</td>
<td>70</td>
<td></td>
<td></td>
<td>331</td>
</tr>
<tr>
<td>3. Meall na Samhna</td>
<td></td>
<td></td>
<td></td>
<td>204</td>
<td></td>
<td></td>
<td>204</td>
</tr>
<tr>
<td>4. Glas Tulaichean</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>Coire Sharroch (8. Coire Fee)</td>
<td></td>
<td>312</td>
<td>324</td>
<td></td>
<td></td>
<td></td>
<td>636</td>
</tr>
<tr>
<td>9. Coire Garbhlagh</td>
<td>250</td>
<td></td>
<td></td>
<td>14</td>
<td></td>
<td></td>
<td>264</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>94</strong></td>
<td><strong>75</strong></td>
<td><strong>707</strong></td>
<td><strong>324</strong></td>
<td><strong>359</strong></td>
<td><strong>1587</strong></td>
</tr>
</tbody>
</table>

Table 3. Summary of woolly willows planted at each site, by year, to 2012.
Achievement of targets

Not all the planted willows had been monitored by the end of the project period. They are not easy to find in the first year or two after planting, although casual checking had proved that there were good numbers surviving at some sites (Figs. 5 and 6). A major monitoring programme in 2013 at Coire Sharroch found promising rates of survival and growth (See details below in ‘New and ongoing work’ section). The only site that has been monitored over several years is Glas Tulaichean where 28 were planted in 1999. By 2003 this number had dropped to 17 surviving plants and in 2007 there were only seven (25%).

In 2012 the opportunity was taken during the planting at Coire Garbhach (Fig. 7) to monitor the 2009 plantings. Fifty-one surviving transplants were seen and measured out of the 250 originally planted. This is a minimum figure as it was not possible to access all areas and some plants may have been missed due to size. This makes it almost certain that this population will have been boosted to well over the theoretical minimum of 50 by 2015, especially with the 14 plants added in 2012.

The number of woolly willows planted, therefore, has to be adjusted if a calculation is to be made as to whether the target number for the total Scottish population of 2000 plants by 2010 was achieved. If we take a possibly pessimistic estimate of 25% survival and assume no significant losses of the ‘original’ (pre-SAF work) plants then the target was narrowly achieved in 2010 (1,838 original plants + 904 planted willows x 0.25 = 2,064). By 2015 this will be a little more secure (Table 4) because of the plantings in 2011 and 2012.

Woolly willows were due to be planted at Caenlochan in 2012, if the areas proposed did not have other botanical interests which might be damaged. Unfortunately this assessment could not be carried out because heavy rainfall made the access track impassable. This planting was rescheduled for 2013 (See ‘New and ongoing work’ section below) and has since made the achievement of the first target even more secure with the addition of c. 200 plants.

The second target of ensuring that populations are stable or increasing by 2015 has now been achieved at 10 of the 13 sites, where the numbers...
of plants are thought to be above 50, although it is not possible to predict that any will be increasing. The position is different for the other three sites. The Glas Tulaichean site can scarcely hold 50 plants because of the grazing levels, and the Ben Lawers and Meall nan Tarmachan sites cannot be supplemented as there is little refuge from grazing. Thus these three sites cannot really be regarded as ‘stable’.

The plantings at Lairig Innein and Creag an Lochain (sites 1b and 2b, Table 4) are not in ‘native’ sites, but are really substitutes for not being able to plant at the original Ben Lawers (Meall Garbh) and Meall an Tarmachan (also called Meall Garbh) sites, and so do not contribute to the third target of ‘increasing the range of the species by ensuring that populations at four sites can expand by 2015’. Both plantings are acknowledged to be experimental as they are south and east facing sites (Mardon, 2000, 2003) whereas all known natural woolly willow sites have a northerly aspect.

Table 4. Projected numbers of woolly willows by 2015. This does not include 2014 plantings at Caenlochan and in Coire Fee (see New and ongoing work section).

<table>
<thead>
<tr>
<th>Site no.</th>
<th>Site Name</th>
<th>Number of original plants at 2012</th>
<th>Number planted by 2012</th>
<th>Number of planted stock surviving to 2015 assuming 25% survival</th>
<th>Projected total number of plants by 2015 (Cols 3 + 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ben Lawers</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1b</td>
<td>Lairig Innein (new)</td>
<td>-</td>
<td>124</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>2</td>
<td>Meall nan Tarmachan</td>
<td>-</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2b</td>
<td>Creag an Lochain (new)</td>
<td>-</td>
<td>331</td>
<td>83</td>
<td>83</td>
</tr>
<tr>
<td>3</td>
<td>Meall na Samhna</td>
<td>102</td>
<td>204</td>
<td>51</td>
<td>153</td>
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<tr>
<td>4</td>
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<td>1</td>
<td>28</td>
<td>7</td>
<td>8</td>
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<td>5</td>
<td>Coire Kander</td>
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<td>Glen Callater</td>
<td>123</td>
<td>0</td>
<td>0</td>
<td>123</td>
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<td>0</td>
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<td>243</td>
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<tr>
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<td>2</td>
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<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>13</td>
<td>Geal Charn</td>
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<td>0</td>
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</tr>
<tr>
<td>Total</td>
<td></td>
<td>1724</td>
<td>1587</td>
<td>397</td>
<td>2121</td>
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</table>
Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

1. Targets for a montane species such as woolly willow take a long time to achieve because of the remoteness of the sites where it grows, difficulties of access and the need to mitigate the causes of decline.

2. Obtaining accurate data to inform the recovery programme takes a long time for similar reasons, and also because of weather limiting survey work, and the need for skilled surveyors. Thus it was fortunate that SAF resources became available just as the WWSG had finally (after eight years) collected reasonably accurate counts at all sites (except one where this was achieved in 2011). There are still four small sub-sites where survey is required (Table 1).

3. The techniques for collecting and propagating woolly willows pioneered by NTS and adopted in this programme worked well. It is perfectly possible to produce large numbers of montane willows, transport them to remote sites and plant them. It takes two to three years from the decision to plant somewhere and identify suitable source material, to the actual planting taking place.

4. Propagation by seed is to be preferred where possible because large numbers of genetically variable plants can be produced, but some propagation by cuttings is useful where plants of known sex are needed or there is a need to boost the number of parental sources.

5. While it was known that deer and sheep can have a serious effect through grazing, it was not appreciated at Coire Sharroch how much damage is caused by mountain hares (Lepus timidus). Grazing of flowering shoots may have a serious effect on seed production.

6. Continuity of the people involved in the programme is important. Some delay was caused by the high turnover of staff in SNH at one site.

Future action

Standardised monitoring of the willows planted is vital if lessons are to be learned from the planting done so far. This is particularly important in evaluating the success of the planting at a micro-habitat level. Repeat surveys of the pre-existing woolly willows will also be necessary at longer intervals to plot their progress, and especially to assess any progress in alleviating problems due to grazing. It will also be important to monitor populations where reducing snow cover may make them more vulnerable e.g. Geal Charn (Coiре Cheap). Lessons learned from the planting programmes should be used in further work to make all the woolly willow populations more secure. The numerical target of 50 plants per population was only a minimum. Security of the existing populations will only be assured when we see recruitment and this will require a good ‘seed rain’ from many female plants.

It is recommended that monitoring of planted willows follows the protocol drawn up by the Montane Scrub Action Group (in preparation). It is also recommended that the monitoring of the pre-existing woolly willow populations follows the method described by Marriott (2008). There have been too many surveys which just result in a count of individual plants. If this is less than that reported in a previous survey it does not necessarily mean that the population has declined, it may simply be that the surveyor did not find all the plants. This problem is illustrated by one project which surveyed three sites more-or-less accurately but missed 30-94% of woolly willows at the remaining four sites.

Any future planting of woolly willows (or any other montane willow species) must take into account the possibility of accidentally introducing pests or disease. Any such planting should have a written protocol to deal with this potential problem which has been agreed with a suitable authority. This should include:

1. A protocol for dealing with vine weevil.
2. A protocol for dealing with rust infections (e.g. spraying with fungicide, only planting when not in leaf or careful checking before planting).
3. A protocol which includes the sterilising of secateurs between taking cuttings.
4. The cleaning of boots between visits to different sites using appropriate chemicals.
Key Management Messages

- There must be good quality data on population numbers and the distribution of a montane willow of conservation concern before proceeding to any remedial action.
- There should be a proper rationale for any action taken, especially showing how the apparent causes of any decline have been addressed. Consideration must be given to the effect on other species of action taken.
- Where planting is considered to be necessary, it will take 2-3 years from the start of propagation to planting. Consideration must be given to the responsibility for future monitoring and its methods before planting.
- Propagation of plants from seed is practicable and ensures genetic variation and presumably gender balance. Seed should ideally come from a minimum of 30 seed parents. Cuttings work well but make it harder to ensure genetic variation and gender balance unless great care is taken.
- Plant health must be taken very seriously so that fungi and other pathogens are not transferred to wild populations.

New and ongoing work since SAF ended

Caenlochan

In August 2014, 228 seven-year old plants from 10 Caenlochan seed-parents were planted out, with no protection, by RBGE staff. These will be monitored to see if a reduction in deer numbers makes establishment possible (N. Frachon, pers. comm.).

Coire Fee

In August 2014, 300 one-year old plants, taken as cuttings from Coire Sharroch stock maintained at RBGE, were planted out by RBGE and SNH staff in Coire Fee, outside the Coire Sharroch fence. These will be monitored to see if a reduction in deer numbers makes establishment possible. They were monitored by SNH staff in 2015 and all had survived well with only one plant showing the effects of grazing (F. Mann, pers. comm.).

Coire Sharroch

The woolly willows (also dark-leaved willow (S. myrsinifolia) and downy willow (S. lapponum)) planted in 2009, 2011 and 2012 were monitored in August 2013 (Marriott, 2014). In four out of seven sites there was over 60% survival of planted woolly willows. The best growth observed was at a site with only 35% survival. At a site with only 31% survival the losses were in more acidic soil, and plants did better in the wetter, flushed part of the site. The willows were monitored again in 2015, and survival and growth rates of woolly willow were maintained (N. Frachon, pers. comm.).

Further Information

- A digital archive of the work of the Woolly Willow Steering Group has been prepared (Marriott and McHaffie, 2013) and is to be stored at RBGE.
References


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The SAF Partners

- *Scottish Natural Heritage*
- *The National Trust for Scotland*
- *The Woolly Willow Steering Group*
- *The Montane Scrub Action Group*
- *Royal Botanic Garden Edinburgh*
The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Hazel Gloves

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Summary

- Hazel gloves is a fungus that occurs in Scotland in Atlantic hazelwoods. These woodlands support internationally important lichen assemblages.
- The main threat is habitat loss due to inappropriate management and lack of awareness.
- Through the formation of the Atlantic Hazel Action Group, a project officer was appointed to provide management advice and promote hazel gloves and its habitat.
- Four woodlands were brought into sympathetic management, three through Scottish Rural Development Plan (SRDP) contracts and one through no-cost changes in management.
- The small size of Atlantic hazelwoods, and lack of overlap with designated sites, made it difficult to fund positive management through SRDP.
- Habitat expansion has been instigated on the National Forest Estate.
- Greatest success was achieved through a huge increase in awareness of hazel gloves, Atlantic hazelwoods and their appropriate management.

Introduction

Why was this species on the Species Action Framework list?

The hazel gloves fungus (*Hypocreopsis rhododendri*) (Fig. 1) was selected because Scotland is a stronghold for the UK population. It was considered to be vulnerable to loss owing to habitat deterioration and accidental habitat mismanagement. Importantly, there was sufficient knowledge of its ecology to inform effective management action. It is a ‘flagship’ species and therefore served to raise awareness of the importance of undisturbed, ancient woodlands and Atlantic rainforest as an internationally important component of Scotland’s biodiversity.

Habitat, distribution and abundance

Hazel gloves is associated with west European hazelwoods that experience an oceanic climate, characterised by high rainfall throughout the year with relatively mild winters and cool summers. In Scotland, this Atlantic hazel habitat is best developed along the west coast and Inner Hebrides islands of Argyll and Bute and Highland. Atlantic hazel is distinct from hazel in other parts of Europe because of the large diversity of epiphytic lichens and other species it supports. The habitat is also part of a globally rare coastal temperate rainforest biome.

Within Atlantic hazel, hazel gloves is mainly found growing on standing, dead stems of hazel, but it has also been recorded on living hazel branches, cut hazel branches and living and dead branches of blackthorn, eared willow and wild rose. Hazel gloves was first discovered in Europe on Mull in 1975. At the start of the project, it was known from 12 10-km squares at 16 sites in Scotland in 2006 (Fig. 2). All of these sites were on the west coast in Argyll or Highland. Species Action Framework (SAF) -commissioned and volunteer survey has now resulted in records from 25 10-km squares and expanded the known Scottish range south to Arran (Fig. 2). One of its best recorded Scottish sites, the Scottish Wildlife Trust’s Ballachuan Hazelwood, is a woodland that may well never have been coppiced and therefore contains a considerable amount of standing dead wood, much of which is hazel.
A. Management that will have serious negative impacts on Atlantic hazel habitats

Coppicing
- Disrupts natural processes of the habitat; all lichens, fungi and bryophytes growing on the hazel will be removed with the cut stems.
- Destroys ecological continuity, resulting in loss of species dependent on this, e.g. mostly crustose lichens of the Graphidion community, but also the larger, leafy-lobed lichens of the Lobarion community.
- Removes shade and reduces humidity to the detriment of species that rely on these conditions, e.g. oceanic bryophytes.
- Reduces fungal diversity.

Continuous heavy grazing
- Disrupts natural processes of the habitat and leads to loss of habitat structure and loss of hazel.
- Natural regeneration by producing new shoots from the base is constantly inhibited by grazing.
- Hazel stools develop unstable growth forms on few stems, with an unnaturally elevated canopy, prone to wind-blow.
- Ground flora trampled and poached, and excessive dung produces nutrient-enriched conditions.
- Loss of species dependent on continuity of habitat conditions within an old-growth stand.

Long-term exclosures
- Can disrupt natural processes of the habitat by excluding occasional light grazing. This leads to loss of glades and build-up of rank vegetation.
- The glade edges to hazel stands are compromised and lost to dense, thicket regeneration.

Scrub clearance
- Destroys the habitat.

Unsuitable siting of cattle feeding stations
- Localized intensive use of areas of Atlantic hazel will result in ground flora being trampled and poached, and excessive dung causes nutrient enrichment.

Rhododendron ponticum
- Invasion by this non-native evergreen shrub results in a general loss of biodiversity, through the effects of over-shading, and toxic leachate from leaf-litter.
## B. Management that will not damage Atlantic hazel habitats, or will have minimum impact if guidelines are followed

### Selective cutting of stems
- A more ecologically sensitive and sympathetic way of harvesting stems from Atlantic hazel. Selective cutting enables the internal integrity of individual stools to be maintained (along with their associated biodiversity), and the cohesion of the stand as an ecological unit.

### Short periods of intensive grazing
- Atlantic hazel has a natural ability to respond to over-grazing for short periods, but extended continuous heavy grazing reduces viability of the stool and the stand.

### Short periods of no grazing
- A respite period from grazing results in a general thickening-up of the stand, and can be useful to allow recovery from periods when over-grazing may have reduced viability within the stand; however, subsequent reintroduction of grazing at low to moderate levels is recommended to keep glades open.

## C. Management that will preserve and enhance Atlantic hazel habitats

### Light seasonal grazing
- Light grazing will ensure glades are kept open, an important habitat feature that benefits a range of wildlife within the hazel habitat. There may be some slight damage to stems, and some basal regeneration will be browsed, but the level should be sustainable.

### Re-introduction of grazing into hazel stands that were formerly fenced to exclude all grazing
- This must be a gradual process, i.e. domestic animals must have access to easy bite as well as struggling through thickets, where animal welfare may be compromised. The aim is to restore glades within a stand that have closed up through thicket regeneration.

### Encourage hazel expansion
- Managing grazing to enable isolated hazel stands or widely spaced clumps to form an integrated habitat (without compromising glade or woodland edge habitats). Needs to be carefully managed.

### Planting hazel to replenish a severely reduced habitat
- Locally sourced hazelnuts carefully propagated in a nursery (protected from mice and vole predation) and well-established saplings can be planted out. Initial protection by Tuley tubes has been important where deer are present, e.g. at Taynish NNR.

## History of decline, contributory factors and current threats

Very little is known about population changes in hazel gloves, however there is assumed to have been an historical decline in Atlantic hazel habitat as a result of what some would call ‘scrub clearance’ for open grazing and other land-use changes. Many Atlantic hazelwoods are small and fragmented, even where suitable soil conditions are present, which is a further indication that the woodlands today were once more widespread. Many Atlantic hazelwoods are also in moderate to poor condition because of a range of deliberate or unintentional management practices (Table 1 and Fig. 3). Table 1 summarises management practices that will have harmful effects on hazel gloves’ Atlantic hazel habitat, but also describes practices with neutral or beneficial effects (from Coppins and Coppins, 2012).
Aims and objectives for 2007-2012

The aims and objectives of the SAF hazel gloves project were to:

• Initiate expansion of Atlantic hazelwood habitat at three to five demonstration sites.
• Ensure that three to five sites, currently in poor condition, are brought into appropriate management for the long-term continuity of hazel gloves habitat.
• Maximise the likelihood that all sites currently in good condition are appropriately managed for the long-term continuity of hazel gloves habitat through effective awareness raising and management advice.
• Compile best practice management advice for the wider Atlantic hazelwood habitat to maintain and enhance the quality of internationally important Atlantic bryophyte, lichen and fungus communities.
• Develop a protocol to assess the condition of hazel gloves habitat in Atlantic woodland.
• Support research to improve the understanding of hazel gloves ecology and specific management requirements.

Fig 3. Causes of hazel gloves habitat deterioration and loss include a) coppicing, b) over-grazing, c) heavy poaching, and d) inappropriate siting of cattle sheds and feeding stations.

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Management Action

Summary of the main action undertaken

- The Atlantic Hazel Action Group (AHAG) was founded to advise and coordinate action. Funding was secured for an AHAG Project Officer.

- Extant locations for hazel gloves were revisited and management requirements were assessed along with the potential for habitat expansion (Coppins et al., 2008). Hazelwoods throughout Argyll were surveyed through volunteer and commissioned surveys. Over 40 community-based volunteers and schoolchildren engaged directly in research and survey.

- Best-practice management guidance was delivered to a wide range of stakeholders through workshops and site visits. Over 80 people attended four workshops and demonstration events.

- The SAF project has resulted in a widespread increase in appreciation of the national and international importance of hazel gloves and its Atlantic hazel habitat. This was achieved through a range of activities such as:
  - media coverage (BBC Landward, local and specialist press).
  - publication of the book *Atlantic Hazelwoods: Scotland’s special woodlands*.
  - Atlantic hazel display at the Royal Botanic Garden Edinburgh (RBGE) in the John Hope Gateway (400,000 visitors use this building every summer).

- Forestry Commission Scotland (FCS) staff assessed opportunities to expand Atlantic hazel on the National Forest Estate. A range of projects are planned or under consideration.

- Twenty landowners were contacted and this resulted in four SRDP applications.

- A PhD was funded to further our understanding of hazel gloves ecology and to improve specific management requirements.

Cooperation

Conservation action requires careful coordination, so a forum was required to bring partners and other interested people together to share information and develop and carry out an achievable action plan.

Although hazel gloves was well known in some circles, Atlantic hazelwoods made a better focus for such a coordination group and attracted the range of people needed to develop and take the plan forward. The Atlantic Hazel Action Group (AHAG) was therefore formed in 2007, a group comprising woodland advisers, lichenologists, mycologists, local biodiversity action plan officers, foresters and SNH staff. In addition to the core group, a wider group of members was kept up-to-date and consulted by correspondence. The group focused on Argyll because it is the main area for hazel gloves, and met two or three times each year. Meetings were hosted by Argyll and Bute Council and chaired by SNH, with action implemented by all members of the group. AHAG is not a formally constituted body, and therefore greatly benefited from the financial management provided by Argyll and Bute Council staff. A website was created to communicate the group’s activities and Facebook and Twitter accounts are being used to alert people to updates.

AHAG was effective as a coordination and advisory group; however, it quickly became apparent that the group needed funding for a part-time project officer to coordinate activities from day to day and to implement specific action. This included providing management and funding advice to hazelwood owners, organising demonstration workshops, coordinating projects and securing additional funding. Obtaining funding for this post was not straightforward and required considerable input from AHAG members, particularly Scottish Native Woods, before action on the ground could be undertaken.

Promoting the importance of Atlantic hazelwoods and involving people

At a first glance it may seem odd to include this as one of the first management actions because it is not direct management. However, unintentional mismanagement was identified as the greatest threat to hazel gloves’ Atlantic hazel habitat. It was recognised at a very early stage that the most important action for AHAG was to raise awareness of the habitat and the types of management that could inadvertently damage or benefit Atlantic hazel habitat quality (Table 1).

Various events were organised to increase the knowledge of local people. Woodland plant and fungus specialists provided training and illustrated talks on aspects of Atlantic hazelwoods. Training
events were organised at Cairndow, Connel, Kilmartin, Ledaig, Appin and Duror. Over 50 people attended these events, resulting in a considerable increase in the number of people with an enhanced understanding of our hazelwoods.

The Isle of Seil Natural History Group already had an enthusiastic membership, and was keen to take part in this project. AHAG was able to assist them with the purchase of specialist survey equipment and with some of the costs of their survey work. The group was very successful, with members finding hazel gloves on five sites.

In an initiative to engage some of Argyll’s future hazel gloves habitat managers, the ‘Floating Hazelnuts Project’ was set up at Easdale Primary School. This experiment aimed to discover whether hazelnuts might have remained viable having floated across the Northern Channel from Ireland. The project involved a visit to Ballachuan SWT reserve to collect hazelnuts (Fig. 4), as well as sessions in the classroom and school grounds to set up the experiment.

One of the most powerful communication outputs of the hazel gloves SAF project was a richly illustrated Atlantic hazel book (Coppins and Coppins, 2012) (Fig. 6). This was launched at RBGE and has been used to raise awareness among key policy makers and to provide a source of income for AHAG through public sales. A summary of the content is also provided on the Atlantic Hazel pages of the SNH website.

A range of media opportunities was used to promote the hazel gloves SAF project through the AHAG. These included articles in the Argyllshire Advertiser, Nature of Scotland, The Botanics and KIST magazines. AHAG members were also able promote Atlantic hazel in a BBC Landward feature.

Atlantic hazelwoods featured in an exhibition at the RBGE’s Hope Gateway (Fig. 5). The Gateway sees some 400,000 visitors every summer. Opportunities like this, achieved through partnerships with institutions such as RBGE, are an important way for relatively small action groups such as AHAG to gain maximum exposure.
Providing advice

Three workshops were organised. A Mull workshop was held in conjunction with the Argyll Islands Woodland Project and a Morvern event in partnership with Plantlife Scotland. Events attracted good attendances (Fig. 7), with a mix of the target audiences of woodland owners and consultants, who provided positive feedback.

Fig 7. Over 80 people attended workshops and events to demonstrate best practice management of Atlantic hazelwoods. © David Genney/SNH

One of the aims of the SAF implementation plan was to develop a protocol to assess the condition of Atlantic hazelwoods for biodiversity. The protocol is published in Coppins and Coppins (2012) and is also available from the SNH website. The first stage requires a wood to be classified into one of four types:

- closed canopy, multi-stemmed stands of pure hazel
- scattered stools in pasture
- veteran stools
- hazel in woodland (including ravines).

The next step is to assess the condition of the hazelwood habitat by answering questions about, for example:

- canopy cover
- stool size
- ground flora
- whether the stems are covered with mosses, liverworts and lichens
- grazing evidence
- number of old ‘veteran’ stools.

Finally, assessors are asked to look for some easily identified indicator species and the general cover of particular groups of species. Each question is assigned a score that is used to assess the relative importance of the hazelwood against a table of threshold scores. The protocol is used widely by a range of stakeholders (Fig. 8) and helped to identify potential woodlands that would benefit from management action.

Fig 8. A protocol to monitor the condition of hazel gloves habitat in Atlantic woodland was developed, tested and published online and in Coppins and Coppins (2012). © David Genney/SNH

The AHAG Project provided woodland-specific management and funding advice and proactively contacted more than 20 woodland occupiers and managers. The principal aim was to offer tailored advice on hazelwood management and expansion and to support SRDP funding applications where applicable. Again, the importance of a project officer is highlighted because volunteers are generally unable to provide the time and expertise required for this task.

Positive management for hazel gloves through SRDP

Where funding was required to implement positive habitat management for hazel gloves, SRDP was one of the few sources of funding. The pros and cons of SRDP as a funding mechanism are summarised in the ‘Lessons learnt’ section below; however, there was some success, illustrated by the following example.

Treshnish hazelwood: a case study

The hazelwoods on Treshnish Farm, Mull, were known to be hazel gloves sites and were included in the initial AHAG surveys undertaken by Coppins et al. (2008). During this phase of the project the presence of hazel gloves was confirmed, the site was described as being in ‘fair’ condition, and the receptiveness of the owners to management advice was noted.
The owners were encouraged to take forward a proposal to fence part of their hazelwoods in order to control grazing impacts on the wood. The management proposals fitted with the SRDP Scrub and tall herb communities option, and the owners were able to include it as part of an agri-environment scheme that was successfully submitted in 2010, with the support of AHAG. The scheme has been implemented and is making good progress (Fig. 9).

‘It’s really important to have easily accessible practical advice for woodland managers, so that they can make informed decisions on how best to look after them. The biodiversity in our wood is improving, which we’re really pleased about’ Somerset Charrington.

The site owners have improved their knowledge of the habitat by attending two AHAG workshops, and are now monitoring the progress of the agri-environment scheme. The site was also used for filming the BBC Landward feature on Atlantic Hazelwoods.

Expansion of hazel gloves habitat
FCS staff have assessed opportunities for expansion of Atlantic hazel on the National Forest Estate. The following case study is an example of a range of projects planned or under consideration.

Hazelwood creation on the National Forest Estate, north Mull: a case study

In this example (Fig. 10), two areas of mature conifer plantation had recently been felled on either side of a burn containing freshwater pearl mussels. This is part of a Special Area of Conservation and FCS is working in partnership with SNH and LIFE Nature to create native woodland in order to improve water quality. Litter input from native broadleaf trees will greatly improve conditions for freshwater invertebrates such as stoneflies and mayflies. These organisms provide food for salmonids – species that act as hosts for the parasitic larvae of freshwater pearl mussel.

The burn has small fragments of hazelwood, rich in Lobaria lichens. Beyond the forest, there is a mosaic of native woodland and other land uses in the adjoining landscape including more extensive patches of Atlantic hazelwood. The very limited seed source around the felled area means that planting will be necessary over most of this, with some room left for expansion by natural regeneration around existing bushes.

In this 11 ha scheme, hazel will be the predominant species planted with minor components of other species, such as wych elm, blackthorn and goat willow, to diversify litter input and match species to planting site suitability. Plants of local provenance are currently being sought for this project.
FCS staff will work with lichenologists and bryologists to monitor the colonisation of planted hazels, and other tree species, by glue fungus, hazel gloves, lichens and bryophytes at this hyper-oceanic site.

Improving management advice

Hazel gloves acted as an important ‘flagship’ species for Atlantic hazelwoods in Scotland because many of the important known sites for the fungus also supported a high diversity of oceanic lichens and bryophytes. On this basis it was possible to provide effective management advice that focused on maintaining the continuity and expansion of a habitat, to the benefit of many internationally important species.

In an effort to refine management advice for hazel gloves, a PhD was funded to investigate the ecological requirements of the fungus in more detail. Some of the findings of this work challenge our perceived wisdom.

Key research conclusions

- Hazel gloves distribution throughout a wood does not appear to be strongly influenced by stand structure and microclimate. This suggests that specific stand-structure management for hazel gloves is not required so long as there is a continuous supply of dead or dying stems infected with the glue fungus. High livestock densities may, however, adversely affect hazel gloves populations through snapping off dead stems.

- Hazel gloves mycelium is not found in the wood of hazel branches; instead fruit bodies appear to be discrete organisms that parasitise glue fungus mycelium where it emerges from stems. This means that fruit body surveys give an accurate reflection of the distribution of the fungus. Survey can take place at any time of year but is best in autumn when fruit bodies are both large and healthy.

- There appears to be very low, if any, genetic variation within the Scottish hazel gloves population. It is not necessary, therefore, to take local genetic diversity into account in future conservation plans.

- Observations from elsewhere in Europe cast doubt on the hypothesis that hazel gloves is restricted to ancient woodland. Thus, the fungus may not be as good an indicator of woodland ecological continuity (an important determinant of lichen diversity) as previously thought.

- Low genetic diversity across Europe suggests a recent population bottleneck. One possible explanation for this is that the European population spread from a single colonist from North America.

- It is predicted that years with a dry spring-to-autumn period will result in a contraction in hazel gloves population size. This is because humid weather is thought to be required for colonisation and growth of fruit bodies and year-to-year population turnover is high.

Although hazel gloves has served as a valuable flagship species to attract attention to the importance of, and threats to, its Atlantic hazelwood habitat, these research findings suggest that hazel gloves does not require targeted conservation action. It is recommended that future action focuses on conservation of the Atlantic hazelwood habitat and its diverse oceanic epiphyte communities as a whole.

Lessons Learnt, Further Work and Future Recommendations

The lessons learnt from the SAF project, and future recommendations, are summarised below under Key Management Messages.

Pros and cons of SRDP for hazel gloves habitat management

The AHAG project encouraged woodland occupiers to bring hazelwoods into favourable management. However, there were strengths and weaknesses to the support mechanisms for Atlantic hazelwood managers.

SRDP prioritised hazel gloves, crediting applications that involved appropriate management of Atlantic hazelwood. SRDP Tier 3 ‘Supporting Biodiversity’ included appropriate management measures in the Scrub and tall herb communities option. The requirements for the option provided a good fit, as this extract shows: ‘The key focus for managing scrub and tall herb communities will be the grazing regime. This will normally involve light grazing in the summer, and none in the winter’. However, during the lifetime of the SRDP, the number of points required to gain entry increased. Initially this encouraged...
land managers to seek out activities that might gain them the required points, and this briefly worked to the advantage of Atlantic hazelwoods. However, the threshold for entry rose and therefore discouraged applicants from attempting to gain entry to the scheme. Informal conversation with local consultants suggested that by the end of 2011 they were not encouraging clients to apply because of the high cost and risk of failure.

The language used by SRDP was also counterproductive in some cases, for example ‘scrub’ continues to have rather pejorative connotations for the agricultural community; they have spent their careers under a regime that supports the removal of scrub, not its management. This concern might have been amplified given the *Eradication of scrub or woody vegetation* option available under Agri-environment capital items. The description for this measure (which potentially attracts over 10 times the grant aid available for Atlantic hazel management) made no reference to any type of scrub that it might not be desirable to eradicate.

SRDP Sustainable Management of Forests (SFM) included options that are appropriate for the management of Atlantic hazelwoods. These included SFM-native woodlands and SFM-woodland grazing. SFM options were removed from the Rural Priorities Regional Proposal Assessment Committee (RPAC) system, and were subsequently administered directly by FCS staff. This worked to the advantage of woodland schemes because forestry measures were apparently not subject to the same financial pressures as supporting biodiversity measures.

Because Atlantic hazelwoods are generally small, there were two significant scale issues that acted as barriers to successful funding. First, the transaction costs of application were high and largely fixed, so small schemes were unattractive. Second, SFM-woodland grazing required a minimum area of 5 ha. This excluded many Atlantic hazelwoods. The SAF project made successful use of SFM at two sites where hazelwoods were part of larger woodland schemes, providing the scale that is necessary to contemplate an application. Both sites were also under the control of occupants who were sympathetic to conservation management.

SRDP included options for the creation of native woodlands, both by planting and by natural regeneration. An Argyll Islands measure provided further incentive to create new native woodlands. The project handled two enquiries about the creation of new hazelwoods under this measure; however, both were untenable owing to the small scale of the proposals.

**New and ongoing work since SAF ended**

- A survey of hazelwoods in mid-Argyll has been carried out for SNH. The survey included a search for hazel gloves, but also assessed the importance of the woods for biodiversity and their condition. The value of the woods will be discussed with the owners, and management advice provided where required.
- Opportunities continue to be explored for expanding Atlantic hazelwood habitat. For example, a clear-felled conifer plantation in mid-Argyll is currently being considered because it has ideal conditions for hazel planting.
- Members of AHAG continue to advise on and influence development of the next phase of SRDP to improve options for management of small Atlantic hazelwoods.
- AHAG is currently exploring funding options. They hope to appoint another project officer to develop and expand the advisory and awareness raising roles of the SAF project officer.
- New locations for hazel gloves continue to be reported via the AHAG online recording form. These records are used to update a distribution map.
Key Management Messages

- Great gains can be achieved by raising awareness to prevent future damage to hazel gloves habitat.
- Guidance on management practices affecting hazel gloves is summarised in Table 1.
- It is important to focus on species that can act as flagships for a habitat and a range of other species.
- A project manager is essential for effective management of a project such as this. Funding for such a post should be secured at the earliest opportunity.
- Funding packages take a long time to pull together and must focus on funders’ priorities rather than specific management priorities.
- SRDP has been ill-suited to the requirements of a species that occurs primarily in small patches of habitat that do not overlap with designated sites.
- Future projects should seek to influence appropriate SRDP options.

Further Information

- [https://sites.google.com/site/atlantichazelgroup/](https://sites.google.com/site/atlantichazelgroup/) – Atlantic Hazel Action Group website.

References


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The Species Action Framework Handbook

This account comes from the *Species Action Framework Handbook* published by Scottish Natural Heritage. For more information on the handbook please go to [www.snh.gov.uk/speciesactionframework](http://www.snh.gov.uk/speciesactionframework).

‘Invasive non-native species’ formed the second group of species for which management was deemed necessary to benefit nature. Here, targeted action is focused on species that are not native, and which are harmful to the wider biodiversity of a given area.

The hierarchy of action in dealing with such invasive species is: prevention, containment and then control. The most effective action is to prevent the spread of invasive non-native species into Scotland in the first place - those species that present a recognised but imminent threat need to be targeted in particular. In Scotland the Non-Native Species Action Group currently provides a lead in coordinating necessary action for such species. However, the SAF concentrated on species that had already established themselves in Scotland. Actions for invasive non-native species can include control measures to reduce their population or limit their spread, or efforts to modify the human activity contributing to their spread (through enactment and enforcement of legislation, voluntary agreements or through education and promotion of codes of practice).

SNH’s priorities related mainly to the control of such species where they affected sites, habitats and species of high nature conservation importance, including genetic as well as ecological threats. Six out of the 32 SAF species were included here. These became the focus of new, targeted effort and resources over the five year project. These met the SAF criterion of being ‘non-native species present in Scotland and assessed as presenting the greatest risk to biodiversity of high conservation value.’

The following species became the focus of new action under this heading:

**Vertebrates**
- American mink
- Grey squirrel (see chapter 8)

**Invertebrate**
- North American signal crayfish

**Plants**
- New Zealand pygmyweed
- *Rhododendron ponticum* and its invasive hybrids
- Wireweed
American Mink

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Summary

• The American mink is well established in Scotland and has a serious impact on a range of vulnerable native prey species.

• Much of this chapter focuses on the Scottish Mink Initiative (SMI), a landscape-scale strategic approach to mink control on the Scottish mainland. This project has successfully reduced the mink population over much of its 28,000 km area with over half of the 24 designated catchments assigned the status of ‘mink-free’ or ‘possibly mink-free’ by September 2013.

• This work relied on a small ‘army’ of volunteers (peaking at nearly 600 in 2012) from local communities to monitor and trap mink using Game and Wildlife Conservation Trust (GWCT) mink rafts. One of the project’s key objectives was to ensure long-term, sustainable control through gradual transfer to local organisations.

• The success of community-based mink control is reflected in the increasing number of volunteers now actively involved and the interest expressed by organisations within and beyond the project. However, volunteer retention is a key issue, especially in areas where mink have become scarce and their evidence is rarely found on the monitoring rafts.

• The SMI has benefited from a strong science input through close links with the University of Aberdeen. An example is the development of an on-line database, increasing the efficiency by which mink monitoring and capture data are reported and collated, and the suitability of the spatial coverage is determined. The new Mink App provides a powerful mechanism for providing up-to-date feedback to volunteers, helping them better understand their contribution to the wider objectives and remain motivated.

• Although the focus of the SMI has relied primarily on volunteers for checking mink rafts and trapping, the experience gained supports the view that a single method of control is unlikely to be the solution in every situation, especially where eradication rather than control is the objective. A range of management tools is needed, such as land-based tracking tunnels, trained dogs and targeted live trapping, possibly using remote systems to monitor traps.

• Two island-based mink control projects are described, illustrating how the targeted approach, to protect specific natural heritage features, can play an important role in the overall mink control strategy.

Introduction

Species background

The American mink (Neovison vison) is a semi-aquatic carnivore that first became established in the wild in Britain in the 1950s following numerous escapes and releases from fur farms. It has now spread throughout most of the country.

Why was this species on the Species Action Framework list?

The American mink met criterion 2 of the Species Action Framework (SAF) as an invasive, non-native species which presents a significant risk to biodiversity (Scottish Natural Heritage, 2007). A generalist predator, it has a serious impact on a range of vulnerable native prey species. It has been well studied, and management options are available to control it locally, which benefits a range of prey species, notably water voles (Arvicola amphibius) and ground-nesting birds.

The Wildlife and Countryside Act 1981, as amended, makes it an offence to release mink, allow them to escape, or cause them to be at a place outwith the control of any person, and (since an amendment order in 2012) prohibits the keeping of the species in Scotland except under licence.

Habitat, distribution and abundance

Mink are associated with aquatic habitats, including coastal areas. Following several introductions in the UK they have spread throughout the mainland except to, as yet, Caithness and most of Sutherland (Fraser et al., 2013). Until recently, they were widespread in the Western Isles (Moore et al., 2003), but have been the focus of a major EU LIFE and SNH funded eradication programme; now only a few survivors remain to be trapped (Lambin et al., 2014). They also occur on several other
Hebridean islands. The Scottish population has been estimated at between 19,450 and 52,250 (+/- 50%). However, capture data from the Western Isles and mainland Scotland suggest that these figures are unreliable.

**General ecology**

Mink are adaptable opportunist predators and exploit a wide range of mammals, birds and fish. The sexes live apart and occupy individual linear territories, at least 2 km in length in Scotland (Melero et al., 2015). Watercourses with plenty of bank-side tree cover are preferred. In coastal areas they prefer more sheltered sites with large rock pools.

Evidence of the detrimental impact of mink on native wildlife is well documented (e.g. Craik, 1997; Aars et al., 2001; Nordström et al., 2003). Impacts on birds can be a result of direct killing of chicks or adults, desertion of colonies, or breeding failures due to disturbance during incubation (Clode and Macdonald, 2002). Widespread, whole-colony breeding failures amongst terns and other seabirds have been unequivocally attributed to mink in the Western Isles, Argyll and Iceland (Craik, 1997; Clode and MacDonald, 2002). On rivers, mink have been shown to lower the breeding densities and productivity of water birds, and there is strong evidence that mink are the main cause of the drastic decline of water voles in Britain. In the far north of Scotland, the internationally important populations of breeding waders, common scoters (Melanitta nigra) and divers (Gavia spp.) would be vulnerable if mink became established in the area. Other species, not closely associated with water, are also vulnerable to mink predation and have potentially been reduced in numbers as a consequence.

Mink are also known to take salmonid fish in many river systems.

**History of invasion and expansion**

The first feral populations of mink were recorded in the 1950s in England. Data on mink colonisation of Scotland were recorded as part of three national otter surveys undertaken from the late 1970s to early 1990s. These data, together with subsequent records, indicate an overall increase in mink, although some anecdotal evidence now suggests that mink may be declining in some parts of Scotland. The spread of mink in Scotland is detailed in Fraser et al. (2013) and summarised in Fig. 1.

![Fig 1. The spread of mink in Scotland from 1965 to 2012.](image)
Maps reproduced courtesy of Elaine Fraser

**Strategic approach to mink control**

In order to ensure that resources are deployed as efficiently as possible and to minimise the potential for mink re-colonisation in controlled areas, SNH takes a systematic and coordinated landscape-scale approach to mink management (hereinafter referred to as the ‘strategic approach’). It takes account of topographical and habitat constraints on where mink can become established, combined with other geographical factors that optimise capture success. This strategic approach has the following key objectives:
• Eradicating feral mink from the Western Isles.
• Preventing mink from becoming established in the Northern Isles and the remaining areas of the north Highlands (mainly Sutherland and Caithness) where the species was thought not to occur at the inception of SAF.
• Systematically removing mink from the extensive area covered by the Scottish Mink Initiative with a view to eventually progressing southwards and westwards from this area as resources and understanding of mink biology in those habitats allow.
• Locally targeting mink control outside this area to protect specific qualifying features on designated sites at crucial times (seasons) and, exceptionally, elsewhere.

Mink eradication from the whole of Scotland is not being considered at this stage, but on-going targeted control is still likely to be required to protect important species assemblages, notably on some of the small Lochaber and Argyll islands e.g. the Glas Eileanan SPA (notified for breeding common terms), the Ulva, Danna and the McCormaig Isles SSSI (notified for breeding cormorant and shag), and the Reisa Islands in the Sound of Jura which support very high densities of terrestrial subterranean-dwelling (fossorial) water voles (Telfer et al., 2003). There are numerous other offshore islands where seabirds have declined as a result of mink predation (Craik 1997), but the above have been identified as priorities for action.

In support of this strategic approach, several projects focusing primarily on mink control were developed and facilitated by SAF. These include:

• The Scottish Mink Initiative (SMI).
• The Reisa Islands Mink Project.
• The McCormaig Isles Mink Project.

Also see the water vole chapter of this handbook, which describes the Trossachs Water Vole Reintroduction Project, in which mink control was a prerequisite for this conservation translocation initiative.

Aims

Objectives for 2007-2012

The strategic objectives above were reflected in the SAF implementation plan for American mink. This identified five main actions for the five-year period of the plan, which were to:
• Eradicate mink from the Western Isles.
• Prevent colonisation of the mink-free area in the north-west and north Highlands.
• Prevent colonisation of the Northern Isles and the remaining Hebridean islands that are currently mink-free.
• Maintain vigilance in the north-west Highlands (where mink are currently thought to be spreading) and initiate an immediate response to remove any live mink reported in this area.
• Within the established mink range, target designated sites for mink management to protect internationally and nationally important populations of vulnerable native species.

Action under SAF

Action implemented 2007-2012

• Eradication of mink from the Western Isles. Although not managed and funded as part of SAF, the Hebridean Mink Project (HMP) which commenced in 2001 has been a key element of the overall strategic mink control plan.
• Implementing the Cairngorms & NE Scotland Water Vole Conservation Projects. Again, these two related projects did not originate through the SAF programme, but as they essentially focused on mink control to protect water voles, they were subsequently combined in 2011 with the NW Highlands Mink Control Initiative (below) to establish a single overarching strategic project – the Scottish Mink Initiative (SMI) that adopted the volunteer-based approach trialled and refined by its predecessors (Bryce et al., 2011).
• Developing and implementing a North West Highlands Mink Control Initiative (2009–11).
The Scottish Mink Initiative (SMI)

This project, implemented over two and half years (April 2011 to September 2013), built upon and expanded the work of the three previous projects (see Bryce et al. 2011). These had established that it is possible to enlist the contribution of large numbers of volunteers from varied backgrounds but with a common interest in co-ordinated mink control. The initial projects also established the need to control mink either over a large spatial scale or not at all, because the very high dispersal ability fully compensates for any mink off-take on a local scale. The previous work also established that much of the uplands represent rather marginal habitat for mink, such that it is effective to protect these large areas by initially removing any mink established there and then creating a buffer area between the cleared upland areas and the more productive lowland areas nearby.

The SMI aimed to effect mink control in a truly vast area with a low edge-to-area ratio, so as to stem the flux of dispersing mink from the periphery. It comprised a partnership between the Rivers & Fisheries Trusts of Scotland (RAFTS), SNH, University of Aberdeen, the Cairngorms National Park Authority (CNPA) and the Scottish Wildlife Trust with the involvement and support of many other organisations. The partnership represented a broad range of stakeholders and relied on an expanding network of over 500 trained volunteers. The overall aim was the protection of nationally significant populations of water voles, salmonids, ground-nesting birds and other native riparian biodiversity by establishing a sustainable management framework to create and maintain an extensive area free of breeding mink. This was to be achieved by the realisation of the following objectives, which were to:

1. Eradicate breeding mink from an area extending from the mid-Tay to the South Esk, around the east coast to the River Nairn; with a belt reaching from Dornoch and Cromarty to Ullapool on the west, preventing mink encroachment to the far north.

2. Ensure the long-term sustainability of mink control in the project areas through the co-ordinated and resourced transfer of responsibility for ongoing mink management to local organisations.

3. Raise awareness of the benefits of the community-based and adaptive management approach to invasive non-native species management.

Background and planning

From the late 1990s, SNH commissioned several studies focusing on the distribution and ecology of water voles in the Cairngorms and elsewhere in north-east Scotland: see Capreolus Wildlife Consultancy (2005), WildCRU (2004) and Lambin et al. (1998). The perilous state of the surviving water vole populations, almost exclusively in headwater streams and ditches around the periphery of river catchments, was attributed to an expanding mink population which occupied the main stems and major tributaries of these river systems. Even upland populations were shown to be declining, albeit at a lower rate than their lowland counterparts. As a result, a community-based mink control initiative (the NE Scotland Water Vole Conservation Project) was established in the River Ythan catchment by the University of Aberdeen with support from SNH. Subsequently, a similar, extensive, multi-catchment project was initiated in 2006 by SNH and the University of Aberdeen in partnership with the CNPA.

In 2008, in response to concerns about the northward spread of mink into the northern Highlands and the associated threat to the internationally important ground-nesting bird populations of the Caithness and Sutherland peatlands, as well as the strong water vole population of the region, SNH part-funded a mink survey of the northern Highlands. The study concluded that there were no, or only a few transient, mink north of the Ullapool-Dornoch Firth line, although there had been a few isolated mink sightings previously. These findings were used to inform a predictive model, focusing on how mink might colonise the area, and to provide a set of management recommendations designed to prevent further expansion in the north (Harrington et al., 2008). The recommended approach was to establish a cordon sanitaire comprising a double line of mink rafts running across the north-west Highlands from the Dornoch Firth in the east to Loch Broom on the west coast. The SAF-funded North West Highlands
Fig 2. Distribution of mink rafts and female/unknown mink captures 2003-2013.

© RAFTS
Mink Control Initiative was established in 2009 to implement this. All three projects employed project officers to coordinate the volunteer-based mink monitoring and control using a network of Game & Wildlife Conservation Trust (GWCT) mink rafts (Reynolds et al., 2004), combined with land-based tracking tunnels deployed in spate-prone rivers where rafts are not practical, as in the case of the north-west Highlands scheme. These tracking tunnels function in a similar way to the mink rafts, i.e. they comprise a wooden tunnel concealing a tracking pad of clay, but are ground-based rather than raft-based.

The integration of these projects into a single strategic effort to systematically remove mink from northern Scotland, using the network of river and fisheries trusts and coordinated by RAFTS, was proposed by SNH in 2009 and resulted in the establishment of the SMI in April 2011, following a one-year gap, with limited bridging funds to minimise the loss of goodwill amongst the partners and volunteers.

**Location of work**

The SMI ultimately operated over about 28,000 km², which was always going to be challenging for a small team of project staff, given the practical limitations imposed by the topography of much of northern Scotland (Fig. 2). The project area was divided into four main operating regions, each with its own dedicated Mink Control Officer (MCO).

**Methods and techniques**

The project relied on GWCT mink rafts (Figs. 3 and 4) as the primary means of detecting mink and then subsequently facilitating their capture. Key to the strategy was to progressively expand the controlled area while retaining a network of detection behind the expansion front. The SMI model was based on a team of full-time project staff operating in defined geographical areas providing support, training and coordination to a wider network of volunteers, fisheries staff and other wildlife professionals responsible for operating the mink raft network.

Within each operating region a network of mink rafts was established at a density appropriate to the needs of the area. Each raft had a unique number and its precise location was recorded by GPS. The GWCT guidance based on productive rivers in southern England recommends one raft per km of river. However, experience from north-east Scotland suggests that a lower raft density may be acceptable in northern Scotland (Bryce et al., 2011). In practice, the density of rafts was variable as it was continuously adjusted based on patterns of mink detection and capture. Particular attention was paid to areas below 300 m, this being the altitude above which mink rarely breed, and to areas where female mink had previously been captured (Bryce et al., 2011). Towards the end of the project a habitat-suitability map was produced by the University of Aberdeen (Fraser...
Training was also provided on trapping procedures, the project staff provided instruction and training as necessary, on how to set up and run the rafts. Training was also provided on trapping procedures, as necessary. This ensured that traps were run and operated effectively and legally, and that appropriate record-keeping was applied. Nine larger training events were organised to promote the project and increase the number of participants.

Detailed information sheets were provided to all the volunteers to help with raft and trap checks. A set of standard operating procedures was developed covering raft positioning and maintenance, health and safety, setting of traps and the humane dispatch of captured mink. To exclude larger non-target species, particularly otters, excluders were fitted to traps. The effectiveness of these excluders was clearly demonstrated as no otters were caught during the course of the SMI.

Initially, in areas with no previous history of raft coverage, the project staff tried to maintain frequent contact with the raft operators. After a good working relationship had been established, the level of contact between volunteers and the project staff could be reduced to a lower level necessary to maintain the successful running of the project (minimum of twice a year).

Mink rafts were checked for footprints, preferably at least once every two weeks, but if not, as frequently as possible. If mink footprints were detected, a humane live-capture trap would be set. Even though the evidence collected by the project was that using bait had no impact on trapping success (Beirne, 2011), where a few trappers elected to use bait (normally fish, rabbit or lure) they were not discouraged from doing so. Once set, the trap was checked once every 24 hours in accordance with best practice. The trap remained operational until a mink was caught, or, if after a period of time had elapsed without capture (ideally five nights), the trap was removed and reset for monitoring purposes. Previous work in the Cairngorms found that that one in four trapping attempts leads to a capture and that the median time to capture is three days. Captured mink were humanely dispatched using an air pistol, according to the protocol specified in the standard operating procedures.

The intention was for all dispatched mink to be appropriately labelled with location and date of capture and then to be retained within freezers and subsequently dissected to provide information on sex, breeding condition and breeding history. In practice, an unknown number were simply disposed of by gamekeepers. Of those carcasses that were processed correctly, subsequent spatial data on female captures have provided an indication of suitable habitat for breeding mink and subsequently refined the selection of priority areas for raft/trap coverage. Originally it was hoped to record the time (number of days) taken to catch each mink (from when traps were set), but the large number of volunteers and lack of easy-to-use data recording systems at the start of the project meant that this was not possible.

The project adopted an adaptive management approach to ensure that management practice was informed by research findings and trapping data. In order to optimise the way in which mink raft data and records of mink sightings are collected and stored and analysed, a web based ‘Mink App’ has been developed by the ‘dot.rural’ Natural Resource Management team at the University of Aberdeen in conjunction with the SMI. The on-line technology is designed to make it possible to collate information from volunteers and project officers and use it to automatically feed-back information on demand.

The emphasis has been very much on expanding the existing volunteer network and developing a sense of ‘ownership’ amongst key local organisations such as the fisheries trusts. Information about the project, including frequently-asked-questions, events, contacts and regular updates, was made available through a dedicated website http://www.scottishmink.org.uk.

The project retained a strong science input from the University of Aberdeen, including a major contribution from a PhD research student, part-funded by SNH, working on the west coast, close to the edge of the mink’s range. This study required mink carcasses for genotyping and stable isotope studies, in order to characterise the mink population in the...
area and suggest routes of northward dispersal. Thus, the frozen carcases of the trapped mink were used for this purpose. Additionally, the information collected from these carcases has informed us about the extent to which mink rely on the west coast as a resource.

Problems and solutions

Data management and storage

The adaptive management strategy for the control of mink demanded an accessible, efficient and reliable data management system. Lack of such a system delays analysis of the impact of management strategies and so can, in turn, impact on the efficient utilisation of the project’s resources. Data from previous projects had been stored on a Microsoft (MS) Access database. However, access to this database was only available to MCOs and as such was ultimately limited. Furthermore, MS Access has its limitations in terms of the size of data sets that it can efficiently manage. There was therefore a clear need to establish a new system that addressed the above limitations. At this time, the University of Aberdeen, through the dot.rural programme, was developing interactive data solutions for rural communities and this provided an ideal opportunity for the SMI. A partnership between the SMI and the university was formed to develop the Mink App. Part of this work was the development of an online database that would not only be accessible to SMI management but also to the volunteers. To make this system operational, data were imported from the original MS Access database and verified systematically from 2011 to 2012. By the end of August 2012 this system had become operational and the data presented here are sourced from the on-line database.

Uncertainty over mink status in West Sutherland

A number of reported sightings of mink in the far north-west, for example around Durness early in the project, resulted in considerable resources being diverted to this area during 2011 and in the first half of 2012. However, despite extensive trapping, monitoring and the use of dogs, no confirmed signs of mink were found, although four polecat-ferrets were trapped or reported dead as road casualties in the area. The lack of mink signs and the presence of polecat-ferrets led to the eventual conclusion that the reported mink were likely to have been polecat-ferrets, and serves as an illustration of the unintended consequences of elevated public awareness following information campaigns. After intensive monitoring and trapping effort over an 18-month period, the project Steering Group decided that resources should be focused elsewhere, while continuing to maintain vigilance in the area.

Mink re-colonisation

Researchers at the University of Aberdeen undertook experimental removal of mink from river sub-catchments and showed that mink could successfully re-colonise unoccupied sub-catchments of 15-30 km length in as little as six weeks during the autumn, post-breeding dispersal period. Furthermore, results from genetic analyses revealed that young mink can disperse up to 100 km from their siblings or parents, easily moving between major river catchments (M.K. Oliver and X. Lambin, pers. comm.).

Devolving management

The SMI was an ambitious undertaking that was based and built upon three previous projects. Originally intended to establish volunteer-based control of mink across 20,000 km$^2$ of Scotland, it was expanded to cover 28,000 km$^2$. This represented a 180% increase in geographic area over a 29-month period when compared to that covered by previous work. This expansion, given the project-based design of the SMI (staff had to cover significantly increased areas and numbers of volunteers), was only made possible through the devolving of management responsibility to local organisations. Although such a handover of management was envisaged towards the end of the first phase of SMI the process actually began midway through the implementation period. This enabled the requirements of this devolved management approach to be identified at an earlier stage. These requirements were then used in the handovers successfully initiated in July and August 2013.

Volunteer retention

In practice, a project that relies heavily on volunteers must accept a degree of attrition of the volunteer pool and this has long been recognised as being one of the most challenging aspects of the community-based approach to mink control. Between the end of the three preceding projects and the start of the SMI in April 2011, there was a period of around 12 months during which matching funding for the SNH contribution to the SMI was being secured, when only a skeleton staff could be retained to maintain the volunteer and associated mink raft networks prior to further expansion.
when new staff would be recruited. Inevitably, this resulted in a drop-off in volunteer involvement in some areas and, predictably, the re-invasion of mink from surrounding uncontrolled areas. A similar phenomenon was noticed in the period between Phase 1 and Phase 2 of the Hebridean Mink Project.

It is necessary to constantly reinforce the message that the continued absence of mink signs on rafts is a positive rather than a negative one. A key technique here is to ensure that volunteers are kept informed of the ‘bigger picture’ so that they understand how they are contributing to the overall goals of the project. The Mink App and associated on-line database provide this facility and offer feedback to the individual on the meaning of volunteers sightings by putting them in the context of the past history of the volunteer’s raft or the contemporary state of the mink population in the volunteer’s vicinity.

Another complementary but longer-term solution may lie in the multi-species approach to mink and other INNS management, namely that the interest of active volunteers can be maintained if they are offered the chance to become involved in the monitoring and control of other problematic riparian non-natives (Bryce et al., 2011). This is the approach that is proposed in the successor to the SMI, in which it is hoped that the network of volunteers already recruited to mink control can form the basis of a wider INNS volunteer workforce, whilst retaining their involvement with mink management.

Paucity of potential volunteers in the remoter areas

Over much of the Highland part of the project area, particularly in the north-west, the low human population density combined with the predominance of deer forest (rather than keepered grouse moor), challenging topography and a limited road network, place significant restrictions on the ability to recruit and retain volunteers. Experience has shown that in areas where there are plenty of gamekeepers rather than a predominance of deer management staff, it is much easier to recruit and retain these individuals into mink control schemes. However, their retention rate in the longer term, once mink have been removed from their patch, is often low (Beirne and Lambin, 2013). Furthermore, with the scarcity or absence of mink over much of the area leading to problems in maintaining the interest of those involved, it was recognised from the outset that maintaining sufficient volunteer (and hence raft) coverage in this area was always going to be extremely challenging. Although this remains a difficult issue to resolve, the experience of the SMI and the associated researchers at the University of Aberdeen indicates that it is possible to harness the considerable support that exists in many small coastal communities. Local tour boat operators (Fraser et al., 2014), fish farm operators, sea kayakers, natural history societies and various others that are active in the coastal environment are often keen to help. The fact that this resource is focused around the coast and the availability of potential volunteers further inland remains very limited is not necessarily a problem. This is because research has shown that mink colonisation of the north-west Highlands has largely been restricted to coastal areas, with mink spreading up the coast from the south, rather than overland via the glens drained by the major rivers flowing eastwards. Stable-isotope work by Fraser (2013) has also shown that mink are more reliant on marine resources in north-west than in south-west Scotland, reflecting the low prey biomass in inland areas in the former.

Partnership working and resourcing

A formal partnership was established between the five main partners, led by RAFTS. Along with SAF project funds, substantial additional finance was secured from various sources including several of the rivers and fisheries trusts (through RAFTS), the LEADER Programme, the Tubney Charitable Trust, the People’s Trust for Endangered Species and the CNPA, as well as an enormous in-kind contribution by volunteers. Five full-time project staff were recruited and employed by RAFTS to coordinate the work on the ground. Additional staff employed by the Cromarty Firth Fisheries Trust and the Ness & Beauly Fisheries Trust provided support in their respective areas, as did the Deveron, Bogie & Isla Rivers Charitable Trust through a separately funded but related project.

Overall management of the project was the responsibility of the project Steering Group made up of the five main project partners and two representatives of the participating fisheries trusts. Technical advice, based upon applied research findings, was provided by the University of Aberdeen and relied on other funding sources.
Fig 5. Spatial analysis of mink monitoring coverage as of August 2013. Note that the assessment does not include the raft locations on the rivers Deveron, Bogie and Isla and the rivers of southern Tayside that are outside the SMI area.

© RAFTS.
Results

Expansion of project area

The SMI expanded mink surveillance and control from its original target area of 20,000 km$^2$ to just under 30,000 km$^2$ through the inclusion of west Sutherland in the project area (Fig. 2). As a result the SMI ultimately covered 24 designated catchments encompassing 45 sub- or smaller catchments, over an area of 28,441 km$^2$, with a water body length of approximately 20,970 km (excluding lochs) and including a significant length of coastline.

The consequences of this expansion were that considerable material and staff resources had to be diverted to this area that had been intended for implementing work in the original project area. To prevent over-stretching of staff resources an early handover was made to two fisheries trusts, the Cromarty Firth Fisheries Trust and the Ness & Beauly Fisheries Trust. This enabled the Mink Control Officer (MCO) for Highland to establish a volunteer surveillance network in the north-west and to undertake targeted surveillance and trapping in those areas not covered by that volunteer network.

Raft, tunnel and trap coverage

In June 2013 a total of 1,019 rafts were deployed throughout the project area, of which 980 were being monitored by volunteers and 39 by MCOs. The monitoring of rafts by MCOs was necessary in areas where there were insufficient volunteers and to verify the lack of mink signs or captures in areas with previously high capture rates (such as Speyside), or with strategic importance (such as the River Shin). The lack of volunteers was particularly true of the north-east extremity of Aberdeenshire, where significant numbers of mink were removed using the MCO-based approach throughout 2012 (Fig. 10).

The level of monitoring was assessed using a model that utilises the suitable habitat data of Fraser et al. (2013) and calculates the coverage of the 2 x 2 km grid cells that are identified as suitable mink habitat (C. Sutherland, pers. comm.). Fig. 5 presents the results of the coverage assessment using data for the location of volunteer-monitored rafts and estates known to be undertaking their own control outside of the SMI at the end of August 2013. Coverage of known sensitive areas and overall coverage throughout the project area, although not optimal, is comprehensive. Even so there are still some areas, for example the far north-east corner of Aberdeenshire and parts of the Findhorn, Lossie, Ness, Spey and North Esk catchments, that require more rafts. Some of the areas with no or poor coverage are isolated upper catchment pockets where there is good surveillance in the mid- and lower catchment areas. However, others are in areas accessible to dispersing mink and are priority areas for coverage in the future.

Not only can the coverage assessment model identify priority areas for future coverage, but it can also predict the number (1,471) and location of rafts that would be required for ideal coverage across the SMI area. The model can also assist with the prioritisation of areas for further coverage. This will be undertaken through identifying suitable mink habitat with insufficient coverage, locations of mink female captures and assessing likely dispersal routes. It is hoped that further research will better define the characteristics of areas that are most likely to be recolonised by female mink. This could enable more strategic monitoring of catchments where resident mink have been removed in the future and ensure more efficient utilisation of resources.

Volunteers

During the interim phase immediately preceding the SMI (April 2010 to April 2011) the number of recorded volunteers fluctuated slightly and was below 200. From the start of the SMI numbers increased quickly, mainly driven by recruitment in the Aberdeenshire and Highland areas, accompanied by more gradual increases in Speyside and Tayside (Figs. 6 and 7). However a data and volunteer verification exercise undertaken from late 2011 to mid-2012 resulted in a net decrease in the number of volunteers recorded as active, primarily in Aberdeenshire and Speyside. As a consequence, the total number of volunteers involved in the project dropped from a maximum of approximately 600 to just over 500 by August 2013. Although the decrease in volunteer numbers was recorded in 2011-12 it was not necessarily the date at which some of them had become inactive. This was because volunteers did not inform the SMI that they had ceased to be active and their inactivity was only discovered after field survey found that their rafts were missing or not being monitored. As such it is possible that some of these volunteers had become inactive before the main phase of SMI had begun.
Fig 6. The number of volunteers involved in mink surveillance and capture 2010-2013.

Volunteer Number

Fig 7. Volunteer recruitment and loss by region and overall 2010-2013.
Volunteers from a broad range of backgrounds participated in both the interim and main phases of the SMI (Fig. 8). The largest numbers of volunteers (289 or 40%) were assigned as residents of the area, particularly in Aberdeenshire, where they were by far the largest proportion. Estate workers such as gamekeepers and factors (collectively 24%) and fisheries personnel including managers, fishery owners, ghillies and anglers (collectively 15%) also made up significant proportions of the volunteers. All the other categories each contributed less than 10%, with other conservation organisation personnel contributing 7%, government agencies and local councils 5%, the tourism and leisure industry 2% and farmers 2%. The ‘Other’ category contributed 6% of the overall total. The composition of this category varied with area, for example in Highland a large proportion of this group were fish farms whereas in Aberdeen it was researchers from its universities.

There were also differences between the SMI areas in volunteer composition, with Aberdeenshire having the highest proportion of residents (58%) followed by the north Highlands (37%), north Tayside (31%) and the Cairngorms (28%). In the Cairngorms, estate and fisheries personnel provided similar proportions of volunteers. Personnel from other conservation organisations were fairly consistent across areas, ranging from 11 to 14 per area. Contribution from tourism and leisure was highest in the Cairngorms at 4%. Farmer contribution varied between 1% for Aberdeenshire and north Tayside and 4% for the Cairngorms and the north Highlands. The latter was mainly composed of crofters.

**Mink captures**

The status of mink populations by catchment is shown in Fig. 9 and the number and distribution of captures during SMI is presented in Fig.10. Following the definition used in the preceding projects, resident mink-free status (presented as ‘mink free’) has been assigned to catchments where no female mink have been caught for at least two consecutive quarters. A further classification of possible mink-free status (presented as ‘mink free?’) has been assigned to catchments where the above definition can be applied but the extent of
coverage could be improved, or where a single mink whose sex was not determined or reported was caught during the last six to nine months of the project. Catchments with ‘active’ status are those where surveillance and trapping networks have only recently been, or are still in the process of being, established and as such would only have had limited if any impact. ‘Active-reduced’ status indicates a catchment where mink captures have fallen markedly since the beginning of the project but there have still been captures of more than one female mink, or mink of unknown sex, in the last six months of the project.

The effect of the SMI on mink populations can be described in terms of its impact on removing resident mink from catchments and on overall population density. According to the mink capture data, 15 (63%) of the 24 designated catchments could be assigned ‘mink-free’ status (10) or ‘possible mink-free’ status (5) (Table 1). However the mink-free proportion of the project area is reduced when considering area (43%) and water-body length (45%).

Of the nine catchments classified as still containing resident mink, four are catchments bordering areas where there is no mink control (Gruinard and Ness), two are catchments where control has now been initiated (the Findhorn and Lossie) and three (the Ugie, Don and Dee) are in or adjacent to the north-east extremity of Aberdeenshire which, with a history of sporadic control, was a known reservoir of mink.

The overall impact of the SMI on mink populations within the project is very consistent, with 84% of catchments, 85% of sub-catchments, 83% of area and 83% of water-body length in the project area showing a reduction or lack of captures (calculated as ‘Sub-total mink-free’ + ‘Active-reduced’). More complex analyses of the mink population size undertaken by Aberdeen University also...
demonstrate that mink populations across the project area are much reduced (X. Lambin, pers. comm.).

In summary, the capture data, work by the University of Aberdeen and the recovery of previously locally extinct water vole populations within the project area, all suggest that the SMI has had a significant impact on mink populations and has continued and extended the work of the previous projects. However, this should not engender a sense of complacency, as research on mink dispersal has demonstrated that there is still a significant risk of re-invasion from remnant populations or individuals within and adjacent to

Table 1. Mink population status in SMI areas in 2013 presented in terms of number and percentage (in parentheses) of catchments, sub-catchments, area and water body length. See text for population status definitions.

<table>
<thead>
<tr>
<th>Population status</th>
<th>Catchments</th>
<th>Sub-catchments</th>
<th>Area (km²)</th>
<th>Water body length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>4 (17%)</td>
<td>7 (16%)</td>
<td>4,965 (17%)</td>
<td>3,522 (17%)</td>
</tr>
<tr>
<td>Active-reduced</td>
<td>5 (21%)</td>
<td>16 (36%)</td>
<td>11,225 (40%)</td>
<td>8,071 (38%)</td>
</tr>
<tr>
<td><strong>Sub-total active</strong></td>
<td><strong>9 (38%)</strong></td>
<td><strong>23 (51%)</strong></td>
<td><strong>16,190 (52%)</strong></td>
<td><strong>11,593 (55%)</strong></td>
</tr>
<tr>
<td>Possible mink-free</td>
<td>5 (21%)</td>
<td>8 (18%)</td>
<td>5,458 (19%)</td>
<td>4,223 (20%)</td>
</tr>
<tr>
<td>Mink-free</td>
<td>10 (42%)</td>
<td>14 (31%)</td>
<td>6,793 (24%)</td>
<td>5,154 (25%)</td>
</tr>
<tr>
<td><strong>Sub-total mink-free</strong></td>
<td><strong>15 (63%)</strong></td>
<td><strong>22 (49%)</strong></td>
<td><strong>12,251 (48%)</strong></td>
<td><strong>9,377 (45%)</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>24</td>
<td>45</td>
<td>28,441</td>
<td>20,970</td>
</tr>
</tbody>
</table>

Figure 10. Number of mink caught by geographic location during the SMI (April 2011-August 2013). © RAFTS
the project area (unpublished data, University of Aberdeen). High numbers of mink captures from the south-east and north-west (Gruinard) of the project area show that there are significant threats of recolonisation from south Tayside and the catchments to the south of Ullapool (Fig. 10). In addition, there is still a threat from residual populations centred on the North Esk and Ugie catchments, both of which have demonstrated lower than expected captures considering the quality of mink habitat and the captures from similar surrounding areas.

Unlike one of its predecessors – the Cairngorms Water Vole Conservation Project – the SMI was not structured or funded primarily as a water vole project. As such, no resources were allocated to monitoring the recovery of water voles following the removal of mink. This decision reflected the composition of the volunteer constituency, dominated by freshwater angling interests, as well as the knowledge that a three-year timescale is very short when considering the process of recolonisation by a species recovering from earlier decimation. Some evidence of the response of water voles to the removal of mink was, however, provided by long term studies undertaken independently by the University of Aberdeen, as well as by multiple anecdotes provided by the volunteers involved in the project. Together, these depict a very strong recovery of water voles at the fringe of moorlands where suitable habitat was within reach of dispersing water voles originating in the upland strongholds that still remained in 2006. For instance, on Deeside, the Balmoral Estate/Invermark water vole metapopulation showed a spectacular recovery in 2008, bouncing back from near extinction to re-occupying its entire range. Water voles also recolonised low ground in Glen Tanar after more than 10 years of absence and also appeared as prey in golden eagle eyries in this area. Multiple sightings by members of the public and volunteers provide further evidence of a recovery taking place in the upper reaches of the River Don catchment (e.g. at Corgarff, Bellabeg, Strathdon and E dinglassie), with now widespread populations in areas surveyed and found to be empty in 1998 (X. Lambin, pers. comm.). The true scale of the recovery, especially the presence of water voles in lowland areas where extensive suitable habitat exists, remains unknown in the absence of systematic surveys. However, there is recent anecdotal evidence of water voles at Corby Loch, north of Aberdeen, for the first time in many years (X. Lambin, pers comm.). While it is expected that more evidence of recolonisation of the upland fringe will emerge, more time will be required before lowland populations are able to re-establish owing to the fact that most are, for now, too distant from sources of potential colonists.

The Reisa Islands Mink Project

These islands off the Craignish Peninsula in the Sound of Jura are not only home to a number of seabird colonies but also hold a unique, high density, fossorial population of water voles. The voles exploit the roots of vegetation across a wide habitat range rather than concentrating on riparian areas as their mainland counterparts would. The island populations of water voles are exceptionally large and dense; spring population densities have been recorded about 10 times higher than on the mainland. The water voles show low genetic diversity within islands but high between-island differentiation (Telfer et al., 2003).

Mink are thought to have invaded the mainland adjacent to the Reisa Islands study area in the 1990s and their predation has had a major impact upon local seabird colonies (Craik, 1997). The available evidence suggests that colonisation of the islands has subsequently occurred. Long-term mink presence on these islands is likely to have a detrimental effect on these island water vole populations, particularly so as natural dispersal and re-colonisation are confounded by geographical barriers.

Water vole numbers have gradually declined across the Reisa islands since the late 1990s. In 2008 there was an unexpected drop in numbers on Coiresa and numbers were lower than expected at Reisa an t-Sruith. Mink are known to have been present at this time.

In addition to the water vole interest, seabird colonies have traditionally been found on both Reisa Mhic Phaidean and Reisa an t-Sruith comprising black guillemot, common tern, Arctic tern, greater and lesser black back gull, common gull, herring gull, oystercatcher and eider. On Reisa an t-Sruith, sustained mink predation has resulted in the complete disappearance of these species.

Objectives

- To protect the breeding populations of water voles on the Reisa Islands and mainland coastline during April, August and September.
• To reduce the local mink population by trapping on the Reisa Islands and mainland peninsula during the rutting and dispersal periods.
• To use data from local landowners on current mink distribution, combined with experience gained each year, to inform future mink monitoring and control efforts on the adjacent mainland.

Planning
At present, the complete eradication of mink from this part of Argyll is not considered feasible. Instead, and in accordance with SNH’s strategic approach to mink management, a targeted approach using carefully positioned traps at key times of year is likely to have the greatest positive impact on the breeding success of the seabirds and the islands’ water vole population.

Location of work
Trapping was focused on the offshore islands of Reisa Mhic Phaidean, Reisa an t-Sruith, Coiresa, Garbh Reisa and Eilean na Cille (Fig. 11), as well as the mainland coastline such as Achanarnich Bay and Craignish Point and, where practical, along potential dispersal corridors along which mink may move into the area (e.g. the Barbreck river). Formerly, trapping was also undertaken by British Waterways on the Crinan canal.

Methods and techniques
The targeted trapping regime employed a network of live-capture traps placed in suitable locations. The extension of the trapping area onto the Craignish peninsula decreased the likelihood of mink by-passing the trap line, in order to maximise the chances of catching them before they can reach the islands.

Fig 11. The location of the Reisa Islands (upper centre and left) in the Sound of Jura. Copyright as Fig 12.
Mink are most easily caught at times when they are most mobile, i.e. during the rut (late February–March), and when the young are dispersing (August–October). Projects elsewhere in Argyll have found trapping in April and August to be most successful. In reality, time, weather and financial constraints are likely to reduce the time available to trap considerably.

Anecdotal evidence from trapping elsewhere on the Craignish Peninsula and in the Western Isles indicates that traps dug in and left in situ produce the best results. Considerable time was devoted in the first year to identifying suitable locations to place traps and cover them. Traps were placed in ideal habitat above HWL with an abundance of large boulders and fitted with wooden baffles to exclude otters.

The in-situ traps were opened to enable a predetermined sequence of trapping to be carried out. For example, during a 10 day period all the traps would be opened on day 1 and checked during days 2 to 9 and then closed on day 10. All traps were checked daily and any captured mink were humanely dispatched using a gas-powered air rifle. A flexible approach was necessary to take account of adverse weather conditions and changes in mink distribution without compromising the requirement for checking traps on a daily basis.

In addition to trapping, GWCT mink rafts were deployed on Coiresa, Reisa Mhic Phaidhean, Reisa an t-Sruith and Garbh Reisa. These were monitored between the April and August trapping periods, providing a measure of the effectiveness of traps in particular locations. Consequently, trapping effort could be targeted specifically to those areas in which mink were known to be present and avoid effort being wasted re-visiting areas already successfully cleared.

**Problems and solutions**

One of the challenges was finding a suitably experienced local boat handler capable of implementing the mink control strategy. As other trapping schemes have found, traps that have already been successful in capturing mink are more likely than others to catch mink again. In the Western Isles, experience has shown that trapping success can be maximised using commercially available mink lure, derived from the scent glands. Baited traps were found to result in more non-target species being caught, although there was no evidence that they were more successful at attracting mink. The remote nature of these islands suggests that they are likely to be an ideal location for trialling the use of ‘Mink Police’ units (see **Further Information** below).

Fig 13: Trapping effort and number of mink caught on the McCormaig Isles, Danna and the Kilmory peninsula, 2007-14.
**Partnership working and resourcing**

The project benefited from collaboration between the contractors and research ecologists from the University of Aberdeen throughout. The contractors’ field observations contributed both to the research element and to decisions on the most appropriate monitoring and trapping strategy. It was agreed that, in addition to the targeted trapping on the islands in spring and autumn, every effort should be made to monitor as wide an area as possible for mink presence and to continue trapping on any part of the mainland considered likely to be a source of colonising mink.

The intention is to reduce the overall trapping effort required over the winter months when weather conditions can reduce consistency, but to remain vigilant and respond to any confirmed mink sightings by placing two or three traps in that immediate area for a limited period. Mink trapping during November to February is usually much less successful than at other times (Craik, 2008), but this reactive approach to dealing with confirmed sightings should help maintain the pressure during the winter period.

**Results**

Overall, the project was successful in utilising the enthusiasm of local naturalists and boatmen to carry out a task that would otherwise be very difficult to achieve.

Trapping was successful on Reisa an Struith and Coiresa Mhic Phaidean where anecdotal observations based on field signs such as the extent of burrow systems, latrines and lawns suggest that water vole populations have subsequently been thriving again (with no evidence of mink).

Furthermore, on Coiresa and Mhic Phaidean, corncrakes have since been recorded calling on these islands for the first time since the late 1990s (J. Dickson, pers. comm.).

**The McCormaig Isles Mink Project**

The McCormaig Isles lie off the Kilmory peninsula, 15 km south-west of Lochgilphead, and comprise Liath Eilean, Sgeir Bun an Locha, Sgeir Dhonncha, Eilean Mor, Dubh Sgeir, Corr Eilean and Eilean Ghamhna. They lie in the entrance to Loch Sween and make up part of Ulva, Danna and the McCormaig Isles Site of Special Scientific Interest (SSSI). Breeding shag and cormorant are both notified features on Corr Eilean and significant declines in their breeding success, originally identified in 2005, are at least partly attributed to mink predation. Furthermore, there is a colony of around 200 common and Arctic terns on Dubh Sgeir, to the south-west of Eilean Mor. These birds are particularly vulnerable to mink predation and the colony has been devastated in the past.

To address these issues, a programme of targeted mink control was needed, taking account of the geography of the area and trapping at critical times of the year, not only to maximise the likelihood of catching mink, but also to protect the breeding bird colonies and reduce disturbance to these areas.

**Objectives**

- To protect the breeding populations of shag and cormorant on Corr Eilean at critical times during the summer months.
- To reduce the local mink population by trapping on the McCormaig Isles and adjacent mainland peninsula during the rutting and dispersal periods.
- To work with landowners to gather information on the current mink distribution, and use the data and experience gained each year to inform future effort.
- To explore the options for long-term control of mink in this area.

**Planning**

The approach has been similar to that adopted in the Reisa Islands, with the ultimate aim of finding ways of consistently trapping mink to provide the best value of money.

Mink control has been carried out on the McCormaig Isles and its surrounds since 2004. Trapping was initially confined just to the islands themselves, but in 2007, the project broadened its focus to include the adjacent mainland peninsula of Kilmore and the nearby tidal island of Danna. The decision to extend the trapping area reflects the realisation that these peninsulas were providing a source of colonising mink. For mink control to be effective, trapping needed to cover both the islands and the nearby mainland.
Fig 12. The location of the McCormaig Isles (Liath Eilean, Sgeir Bun an Loch, Sgeir Dhonncha, Eilean Mor, Dubh Sgeir and Eilean Ghamhna) and the nearby mainland peninsulas.
Location of work

To better understand and rationalise how trapping effort was focused across these disparate islands (see Fig. 12) three separate trapping zones were defined: Zone 1 covered the McCormaig Isles, including Eilean Mor, Corr Eilean, Eilean Chamhna and Dubh Sgeir; Zone 2 covered the adjacent mainland including the associated tidal island of Danna; and Zone 3 covered the mainland peninsula of Kilmory.

Methods and techniques

Trapping was undertaken across all zones during the rut in March when mink are most active. Further trapping took place in late April to ensure that no animals were on, or able to get out to the islands prior to the start of the bird-breeding season. The final session of trapping took place in August to target dispersing mink. The project aimed to identify and establish four ‘magic trap’ locations, i.e. localities with the greatest chance of intercepting passing mink. Some mink trappers in Argyll have used this term to describe certain trap positions that are consistently effective at catching mink. There appears to be no reliable method of identifying such trap locations; it seems to be largely down to luck or trial and error. The fact that these traps capture mink repeatedly may indicate a productive territory which is rapidly re-occupied once the territory holder is removed. If indeed it is a reflection of the relative quality of the territory, then in order to identify the criteria behind the success of these traps we need to better understand mink territories and the aspects of their habitat that are most important. In particular we need to understand how mink use their habitat during the key periods of rut and dispersal when movement is greatest, and trapping in general is more successful than at other times of the year.

Problems and solutions

The requirement for traps to be checked daily means that setting, checking and the closure or removal of traps is often highly labour- and time-intensive on such remote and scattered islands. It was therefore necessary to identify ways of maximising the efficiency of the task. Feedback from the 2007 trapping sessions was used to make changes to the 2008–10 programme, such that the project made better use of every boat trip, thereby improving the efficiency and cost-effectiveness of the project. Traps were deployed at the start of the trapping period and left in situ to enable a predetermined trapping sequence to be carried out. Wherever practicable, traps were set so that the door was visible from the boat. A typical trapping sequence would run as follows: Day 1– set traps; Days 2 to 5 – check traps; Day 6 - close or remove traps.

Previously, trapping occurred only on the McCormaig Isles during late April. This was to ensure that breeding birds had the best possible chance of raising young successfully in the absence of mink predation. On the advice of the trapper, however, it was concluded that it would be a more productive and efficient use of the boat to trap Danna and the Kilmory peninsula as well. In recent years several ‘magic trap’ locations have been identified and these are found to be much more successful in catching mink than others. The number of trapping locations has subsequently been reduced again to concentrate effort at these ‘magic trap’ locations on Eilean Mor, Corr Eilean, Danna and Eilean nan Leac. This reduces effort/time lost in checking unsuccessful traps.

Partnership working and resourcing

The McCormaig Isles trapping area covers land belonging to four separate owners, all of whom collaborated with the contractor. With no option for financial support for mink control under the Scottish Rural Development Programme, SNH offered the contractor a contract that would secure management of the mink problem on the islands for five years.

One advantage of a multi-year project is that if the distribution of mink changes, the project can take account of this. The value of such flexibility was demonstrated in 2007 when a landowner notified the contractor of mink sightings south of the trapping area on the Kilmory peninsula. Two animals were subsequently caught.

Results

Fig. 13 shows that the trapping effort (expressed as the number of trap-days) remained relatively constant from 2007 to 2010 and then dropped to a new lower, but relatively constant level thereafter. It also shows the marked reduction in the number of traps deployed during the latter years (2011 to 2014). An analysis of trapping efficiency shows that, although the number of mink caught each year after the reduction in trapping effort in 2011 was significantly less than previously, this
was offset by a much greater increase in trapping efficiency. Thus, the number of mink caught (per trap deployed) significantly increased after 2010, as did the proportion of traps that caught mink. Although the SAF funding ended in 2012, since 2011 the number of mink caught each year has not differed noticeably. This highlights the increase in efficiency of the trapping effort as time progresses and new techniques and ways of working are developed, notably the identification of so-called ‘magic trap’ locations. The fact that the local mink population is not being reduced, merely ‘harvested’, is not necessarily a problem here, because the primary aim is to remove predation pressure at critical times for the breeding seabirds, not to eradicate mink from the area.

Further work is needed to establish whether it is the trapping effort that is limiting the number of mink being caught. Some locations seem to be more productive than others, for example traps located on Danna seem to consistently catch mink, this may be indicative of the route they take across to the islands from the mainland. In future years trapping effort could be adjusted to further investigate these hypotheses by increasing the number of days on which the traps are active and by increasing the number of traps in those areas which consistently produce mink, particularly Danna as a potential gateway from the mainland. The Reisa Islands trapping project has enjoyed considerable success through identifying potential colonisation routes from the mainland and focusing trapping effort in these areas.

SNH site condition monitoring data for 2004, 2010 and 2013 on cormorants breeding at the site indicate that numbers appear to have remained stable since 2004 when targeted mink trapping started, although it is unknown to what extent the trapping has contributed to this. Equivalent data for breeding shags show that numbers have continued to fluctuate but are still significantly lower than the baseline (expressed as the mean of the counts from 1987 to 1991). This suggests that mink predation is only one of a number of factors influencing the breeding success of these birds.

Lessons Learnt, Further Work and Future Recommendations

The SMI and its predecessor schemes have been hugely successful in harnessing and coordinating the enthusiasm of volunteers (Bryce et al., 2011). This has been shown to be an efficient and highly cost-effective approach to significantly reducing mink numbers over very large mainland areas, to the benefit of native wildlife. However, relying solely on volunteers to maintain the network of mink rafts has its limitations, and similar projects in the future will require continuing financial support to ensure their maintenance and progress. With over 1,000 mink rafts in operation across the SMI area, around 20% needed to be replaced annually because of losses, during spates for example, and general wear-and-tear. This cost at least £10,000 per annum just to maintain the network. Recruitment of new volunteers was also required to make up for losses.

The ultimate objective of the SMI was to engender a sense of ownership of mink management at the local level, as well as wider biosecurity and biodiversity issues, among the local fisheries trusts. Some trusts have now taken on responsibility for the issue in their operating areas, which is an indication of some degree of success in this regard. However, when areas are cleared of breeding mink the retention of volunteers becomes increasingly difficult, despite assurances that a consistent lack of evidence of mink on the rafts is a positive sign. A possible solution lies in the multi-species approach to INNS management, whereby the volunteer network is encouraged to become involved in the monitoring and control of a suite of priority riparian INNS, in addition to mink.

Because the SMI operated in a mainland area, albeit one bounded by the sea on a large portion of its perimeter, some influx of mink will continue, hence vigilance must be maintained. Where the area abuts onto uncontrolled areas, substantial mink incursion will continue and lapses in control effort would potentially affect the wider area. Thus maintaining motivation, interest and pride in the conservation success achieved is paramount.

The handover of responsibility for mink management to three of the fisheries trusts through financial support to deliver a programme of agreed activities made the task more manageable, but in the long term, with further southward and westward
expansion, much greater emphasis will need to be placed on this approach. For example, agreed work programmes to deliver mink control in each of the trust areas could be established in return for a management grant administered by RAFTS. This would cover the management and staff costs incurred by each trust in undertaking a combination of mink raft checking and maintenance, as well as data collection and support and coordination for the local volunteer network. There would still be the need for a project coordinator, whose role is likely to be more strategic and focused on ensuring delivery of the agreed work plans, than was the case in the SMI.

The SMI has benefited substantially from the continuing association between researchers at the University of Aberdeen and the project staff involved in mink removal. The dot.rural project is one example of this. Another is the application of the findings of the closely-related PhD study focussing on the pattern of mink colonisation in the north-west Highlands. The evidence from this study is that range expansion in this region occurs along the narrow coastal zone and not via river catchments to the south and east, as was previously thought (Fraser et al., 2013). The importance of the coastal zone in mink dispersal is consistent with some of the predictions of an earlier modelling study by Harrington et al. (2008) in which it was noted ‘that mink were able to break the cordon sanitaire on the west coast even with the strong control strategy’. Thus, it appears that the original ‘cordon sanitaire’ approach is not an effective means of preventing further northward spread of mink, and instead, effort should be focused in coastal habitats.

In 2015 a detailed analysis of the SMI trapping dataset was undertaken, in which it has been possible to identify the preferred breeding areas for mink from capture data and use this information to develop a more efficient and highly targeted trapping strategy for the future. This analysis has also confirmed the field observations of the Argyll trappers (above) concerning ‘magic trap’ locations.

The success of remote SMS-based mink trap monitoring devices or ‘Mink Police’ (see Further Information below) in the Hebridean Mink Project suggests that they could be used more widely in remoter parts of the country such as the islands, where access is very costly, or in those mainland areas that are particularly attractive to dispersing mink. Provided there is a reasonable mobile phone signal these devices are worth considering, in order to complement the raft-based approach over the remainder of the SMI project area.

In common with the experience of the Hebridean Mink Project and the SMI, the value of dogs in detecting mink was clearly evident on the Reisa Islands. The trappers testified to the fact that, better
than any trap or raft, dogs provide the most reliable indication of whether mink are present in a particular area. If mink scent is detected a dog will instantly indicate that there is trapping work to be done. Conversely, the team know that, if upon landing on the islands a dog shows little or no interest, they can save their time and move on to the next site.

In the context of the wider strategic approach to mink management, the Reisa and McCormaig Isles projects were identified as priorities for action, but a more comprehensive assessment of other sites outwith the current SMI area, where targeted mink control is also a priority, is recommended.

Although not part of these SAF-funded projects, it is worth mentioning the work of Clive Craik at South Shian near Oban in which it has been demonstrated that tern rafts are a very effective means of protecting seabirds from mink. Rafts like those at South Shian, when used in conjunction with mink trapping projects, can offer a safe haven for nesting seabirds in areas where mink are still present, as the rafts are designed so that mink cannot gain access. Where entire colonies have been decimated by mink predation, tern rafts can offer a means by which numbers can begin to recover while mink trapping is underway.

Further Information

- [http://www.minkpolice.com/staticpages/home](http://www.minkpolice.com/staticpages/home) - the website for the Mink Police trap alarm system.
- [http://www.dotrural.ac.uk/minkapp/](http://www.dotrural.ac.uk/minkapp/) - the website for the dot.rural project at the University of Aberdeen that developed the Mink App.
- [http://www.nonnativespecies.org/home/index.cfm](http://www.nonnativespecies.org/home/index.cfm) – the website for the GB non-native species secretariat, the joint Defra, Scottish Government and Welsh Government coordinating body for INNS control in Britain.

References


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The SAF Partners

- Rivers & Fisheries Trusts of Scotland
- University of Aberdeen
- Cairngorms National Park Authority
- Scottish Wildlife Trust
- Scottish Natural Heritage

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

North American Signal Crayfish

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Summary

North American signal crayfish have been present in Scotland since at least 1995. Although they are now known to be present in a number of catchments, their overall distribution remains limited. This species can have a significant impact on other aquatic species and their habitats. Once established, there may be few opportunities for containment, and eradication can often be impossible to achieve.

The inclusion of North American signal crayfish within the Species Action Framework (SAF) has allowed partners to:

- Determine the extent of crayfish distribution within Scotland.
- Promote awareness of the ‘crayfish issue’.
- Identify key ecological impacts on species of high conservation concern, such as Atlantic salmon and freshwater pearl mussel.
- Evaluate current approaches for crayfish control and investigate techniques such as the use of biocides and in-stream barriers.
- Carry out trial eradication projects.

Introduction

Species background

The North American signal crayfish (Pacifastacus leniusculus) is a non-native species. As its name indicates, this species is native to North America, where it is found in the Canadian province of British Columbia and the western US states of Washington, Oregon, and Idaho. Within Europe, signal crayfish were introduced to Sweden from North America during the 1950s and significant numbers were brought to Britain from mainland Europe in the 1970s, predominantly for aquaculture. They were first recorded in Scotland in 1995, from the Kirkcudbrightshire Dee catchment.

Where they occur, signal crayfish are considered to be a ‘keystone species’ (i.e. one that has a disproportionately large effect on the communities in which it occurs) and can have a significant adverse impact on both their environment and other aquatic biota. In Scotland, signal crayfish populations are causing significant changes to biodiversity through increased grazing and predation pressures, and contributing to habitat degradation through bankside burrowing and in-stream bioturbation. Through these activities they may also have an adverse impact on fish and the fisheries that they support.

The population biology and ecology of signal crayfish, both in the UK and other parts of Europe, is relatively poorly understood. This has influenced the wide array of methods that have been used in attempts to control or eradicate them.

Distribution in Scotland

Signal crayfish were imported to Britain in the 1970s to satisfy an interest in crayfish farming (Holdich et al., 2014). Once introduced, escapes from farms and deliberate illegal releases resulted in the establishment of new feral signal crayfish populations over large areas of England and Wales. Although crayfish farming no longer takes place, new populations continue to be reported. Several records exist of signal crayfish introductions to Scotland during the 1980s and there is some anecdotal evidence to suggest that crayfish were translocated to a variety of locations, including Arran, Burntisland, Glasgow, Inverness, Jedburgh, Kirkcudbrightshire, Lochgilphead, Oban, Rothesay and Tayside (Maitland et al., 2001).

In 2010, an assessment carried out by the Rivers and Fishery Trusts of Scotland (RAFTS) estimated that approximately 174 km of river length, encompassing 23 separate rivers and streams and 18 standing waters, were infested. Since that date signal crayfish populations have been verified in another 11 running water and six standing water sites.

Signal crayfish populations now extend from the border regions of Scotland (Kirkcudbrightshire Dee, Nith and Tweed catchments) to the Highlands (Nairn catchment). Most of the known populations are located in south-west Scotland (Galloway) and the Central Belt (the Clyde catchment), but well-established populations have also been recorded in east coast rivers (Tay and Esk catchments) and in the west (Ballachulish). Despite this widespread distribution, most populations are discrete and are narrowly distributed. There are significant geographical distances between most populations, strongly suggesting that they have not arrived in receptor water bodies by natural means.
General ecology

Signal crayfish (Fig. 1) are omnivorous and consume a wide range of food items, including algae, macrophytes, benthic invertebrates, amphibians, fish – and other crayfish. This means that this species has the ability to adapt its diet to take advantage of available food resources. It is notable among crayfish species for its wide environmental tolerances, allowing it to colonise most freshwater habitats, including rivers and streams, lochs and ponds.

Fig 1. North American signal crayfish
© Colin Bean

The size and density of signal crayfish populations are determined by both food and habitat availability. Ontogenetic changes in both diet and habitat use take place as individual crayfish complete their life cycle.

Individual growth rates, as well as population growth, can vary significantly between sites. Adults can attain a large body size (more than 15 cm total length), and can reach sexual maturity after only two years. In exceptional circumstances, signal crayfish can become sexually mature after one year. The signal crayfish mating season occurs in September and October and is strongly influenced by declines in temperature and photoperiod. Once fertilised, eggs are incubated while attached to females for a period of 166-280 days. Hatching occurs during late March to July depending on location (latitude) and temperature. Females can reproduce many times during their lifespan, carrying between 110 and 500 eggs on each occasion.

Movement and spread

The ability of signal crayfish to tolerate a wide range of environmental conditions has facilitated the natural and deliberate movement of this species to a wide range of habitats within the UK. Once introduced to rivers or streams, signal crayfish can either stay within the confines of a small home range, or spread upstream and downstream. Imhoff et al. (2011) suggest that while the downstream rate of expansion can be relatively slow, range expansions can typically be 1 km per year. However, this depends on a number of variables, including habitat suitability, habitat accessibility and hydrology. Perhaps unsurprisingly, the rates of upstream movements tend to be slower than those downstream (Holdich et al., 2014). Signal crayfish are able to negotiate some weirs and natural waterfalls, and can also invade new habitats by utilising marginal wetted (and occasionally dry) areas. High flows can also impede their rate of movement upstream, but conversely high flows and spates can help to disperse crayfish, particularly small juveniles, downstream to new areas.

The methods by which signal crayfish are spreading to new locations within Scotland have come under significant scrutiny in recent years. New records continue to be received each year and populations of signal crayfish are now established in a range of freshwater habitat types (including still-water fisheries). The pattern of distribution, and the fact that these water bodies are not hydrologically connected, strongly suggest that these new populations are the product of either deliberate introductions, or accidental contamination of fish translocations.

In summary, the key activities that are known to have been responsible for signal crayfish spread in Scotland are intentional release for exploitation, natural movement of adults and juveniles after introduction, deliberate introduction as a means of removing dead fish from fisheries, and deliberate introduction of crayfish to garden ponds. Activities that have the potential to translocate signal crayfish to new areas include: accidental ‘hitch-hiking’ in water used to transport fish for stocking;
water transfers between, and across, catchments; extraction of material (such as gravel) from infested sites and re-use in other water bodies; fishermen (illegally) using live crayfish for bait or as an alternative food source for fish; and animal vectors (such as mammals or birds). Accidental transfers may involve the smaller juvenile stages, which are less noticeable and are more likely to be displaced.

Impacts

The ecological impact of signal crayfish on native biodiversity and habitats can be significant and these are reviewed by Holdich et al. (2014). As a keystone species, signal crayfish can cause significant changes to the equilibrium of native flora and fauna through exerting increased grazing and predation pressures. In-stream competition with salmonids, the mobilisation of sediment and direct predation mean that signal crayfish introductions can pose significant risks to species such as Atlantic salmon (Salmo salar) and trout (Salmo trutta). Zu Ermgassen and Aldridge (2011) noted that signal crayfish exhibited ‘optimal foraging’ behaviour when feeding on molluscs, consuming significantly more of the smaller size classes with thinner shells. This suggests that species of high conservation value such as freshwater pearl mussel (Margaritifera margaritifera) could also be at risk from crayfish introductions.

Signal crayfish also have the potential to contribute to habitat degradation through burrowing and this can lead to a loss of river-bank integrity, resulting in increased erosion potential, with implications for flooding, livestock safety and subsidence problems to adjacent infrastructure. This suggests that signal crayfish can have an adverse impact on ecosystem services where they occur within the UK (Everard et al., 2009).

Legislation

Significant changes to legislation relevant to the management of signal crayfish took place during the SAF project. Section 14 of the Wildlife & Countryside Act 1981 has, since its inception, made it an offence to release or allow to escape into the wild any animal that is not ordinarily resident in, or is not a regular visitor to, Great Britain in a wild state. This Act was amended by the Wildlife and Natural Environment (Scotland) Act 2011 (WANE Act) to enable Scotland to adopt the internationally recognised three-stage approach to dealing with invasive non-native species. These stages are: 1) prevent the release and spread of non-native animal and plant species into areas where they can cause damage to native species and habitats and to economic interests; 2) ensure that a rapid response to new populations can be undertaken; and 3) ensure that effective control and eradication measures can be carried out when problem situations arise.

These changes also introduced a ‘general no-release approach’ which make it an offence to: 1) release or allow to escape from captivity any crayfish to a place outwith its native range; 2) release or allow to escape from captivity any crayfish; and 3) cause any crayfish outwith the control of any person to be at a place outwith its native range. These legislative changes also give Scottish Ministers powers to prohibit by order the sale of invasive animals. No licences for commercial exploitation of signal crayfish have been issued.

Another significant change was the introduction through the WANE Act of a new regime of Species Control Orders into the 1981 Act. This enables relevant bodies (Scottish Ministers, Scottish Natural Heritage (SNH), the Scottish Environment Protection Agency (SEPA) and the Forestry Commission Scotland (FCS)) to make a Species Control Order setting out measures that must be taken to control or eradicate an invasive non-native animal or plant. A Code of Practice issued in 2012 under a new section (14C) of the 1981 Act also identified SEPA, through a new Framework of Responsibilities, as the lead body for the control of aquatic non-native species. SNH’s role is to ensure that the Framework operates effectively, as well as providing an oversight of delivery and implementation of non-native species policy in Scotland. However, within its statutory licensing function, SNH retains responsibility for the issuing of licences for the possession of crayfish.

At present, all keeping and movement of signal (or any) crayfish species is prohibited in Scotland, except for the purpose of authorised survey or research. Despite the presence and spread of signal crayfish in Scotland, the legislative provisions relating to their control are considered to be stronger than those available elsewhere in the UK. This led to the tabling of a Westminster Early Day Motion that called on the UK Government to give urgent consideration to emulating Scottish biosecurity controls for signal crayfish, and to ban all keeping and movement of this species in England and Wales.
Action before 2007

Before the SAF project, work on signal crayfish in Scotland (and indeed the UK) was disjointed and uncoordinated. This reflected the absence of the Framework of Responsibilities (now outlined within the 2012 Code of Practice) which identifies SEPA as the lead body for dealing with aquatic non-native species.

In the period from the first record of signal crayfish in Scotland in 1995 until the start of the SAF programme SNH led a number of projects that aimed to remove signal crayfish using ‘conventional’ sampling methodologies, such as hand-removal and electrofishing (Sinclair and Ribbens, 1999). This work established that such removal measures were not effective. SNH also funded a long-term removal experiment in the Upper Clyde (Reeve, 2004), and the first attempt to remove crayfish from a small standing water using a natural pyrethrum biocide (Pyblast) (Peay et al., 2006).

The Scottish Government, through Marine Scotland Science (MSS), provided support for the confirmation and logging of new records. This was discontinued in 2008.

Aims

Aims and objectives for 2007-2012

The overall aim of the SAF implementation plan for North American signal crayfish was to establish baseline information on the distribution and spread of this species in Scotland, improve understanding of control and eradication techniques and prevent further spread. The key objectives were to:

- Increase public awareness of North American signal crayfish as an invasive species and the need to prevent its spread.
- Assess the distribution and status of North American signal crayfish populations in Scotland.
- Take practical action towards the eradication or containment of North American signal crayfish in Scotland.
- Promote and enable a coordinated approach to invasion by North American signal crayfish in Scotland and other parts of the UK.

Management Action

Raising awareness

Action for water voles undertaken as part of SAF Raising awareness of the impact of signal crayfish was achieved in a number of ways. The first step was the development and distribution of leaflets to inform the public about the dangers of introducing signal crayfish to new waters, and to encourage the reporting of new locations to SNH, SEPA, and Rivers and Fisheries Trusts of Scotland (RAFTS). Additional resources went into the preparation and installation of signage in areas where signal crayfish were already known to be present (such as Galloway) to inform members of the public about the dangers and illegality of moving this species to new locations.

The presence of signal crayfish, particularly in areas such as Galloway and the Clyde catchment, generated considerable local and national media interest. This gave the opportunity to publicise the impact of signal crayfish and the need to control their spread. It also afforded the opportunity to raise awareness more generally of the problems caused by invasive non-native species. The scientific community became involved through participating in relevant conferences and publishing information in conference proceedings and peer-reviewed scientific papers.

Establishing partnerships

The management of signal crayfish in Scotland requires a national approach. An initial meeting was held with a range of Government and non-government stakeholders in June 2008 to develop specific actions and explore ownership of tasks. These tasks included identification and verification of new records, record keeping, monitoring and control or eradication. The scale of the problem, and the fact that control was likely to be, at best, difficult and, at worst, unachievable, meant that the development of a partnership approach was challenging.

Despite this, significant partnerships were formed, particularly with the universities of Glasgow and Stirling, with the network of fishery trusts (through RAFTS) and with SEPA. The establishment of partnerships with local organisations who are familiar with, and have access to, affected water bodies was essential. Through these partners it was possible to obtain contemporary data on crayfish
distribution and gain access to sites for eradication trials. Partnerships with universities allowed the project to tackle gaps in fundamental knowledge, such as the ability of crayfish to move within watercourses (Fig. 2).

**Fig 2. Learning more about the distribution and spread of signal crayfish through a research partnership.** © Colin Bean

### Building capacity

Despite being present in Scotland since (at least) 1995, little expertise was available on the monitoring or management of signal crayfish in Scotland. Some experience was available within Government (MSS) and SNH, but not elsewhere. One of the key outputs of the SAF project, therefore, was to build capacity within the freshwater and fisheries management sector. Three capacity-building workshops were held in 2008-09 to provide advice to fishery trust and District Salmon Fishery Board biologists, as well as SNH, SEPA, Scottish Water, local authority and police staff, in aspects of signal crayfish sampling, identification, biology/ecology, containment/eradication and legislation (Fig. 3).

**Fig 3. Building capacity by training others in aspects of crayfish biology.** © Colin Bean

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### Understanding signal crayfish biology

At the beginning of the SAF project the ecological impact of signal crayfish was not fully understood. Research funded under the Species Action Framework (SAF), in partnership with a range of academic, fishery trust and private sector partners, resulted in the completion of various scientific, monitoring and management tasks that have pushed Scottish crayfish research to the forefront of signal crayfish management in the UK. There were significant gaps in our understanding of the impact of introduced signal crayfish on species of high conservation value, such as Atlantic salmon, freshwater pearl mussel and lamprey species. The SAF project, in partnership with Glasgow University, SEPA and the Clyde River Foundation, funded and supervised a PhD research project that aimed to provide an insight into the mechanisms, and potential scale, of any impact on these species. The outputs of this work can be found in Gladman (2012) and Gladman et al. (2009, 2010, 2012). It was concluded that, although signal crayfish do not locate and prey on Atlantic salmon eggs, they have the potential to consume larval fish after hatching using movement and chemical (odour) cues. Subsequent research (Edmonds et al., 2011) confirmed this to be the case. Although Gladman (2012) found no evidence of direct predation on freshwater pearl mussel, mussels of all sizes were displaced from the substrate by signal crayfish as they sought to gain access to the soft interior of the mussel.
Evaluating management options

It is now widely accepted that the control or eradication of established signal crayfish is difficult and, in most situations, impossible to achieve. A SAF-funded review of management options for signal crayfish (Freeman et al., 2010) considered a wide range of approaches for dealing with signal crayfish in Scotland, including biological control.

Removal

SNH-funded research has demonstrated that once signal crayfish have become established, it is virtually impossible to remove them from running waters and large water bodies. A range of techniques have been used in this work (see Gladman, 2012 for a review), including long-term intensive trapping. This has proved ineffective in preventing the spread of signal crayfish within the Upper Clyde catchment. In ponds or small lakes, however, the application of a non-crayfish-specific biocide (Pyblast) has provided the opportunity to remove this species permanently. Three trial areas were either treated or monitored during the SAF project. These included ponds in the North Esk catchment (at Drumtochty and Edzell), Strathardle (Ballintuim) and a flooded quarry pond in Ballachulish (Fig. 4). Post-treatment monitoring of these sites (which extended to five years) have now finished in the first two treated areas. These showed partial success, with crayfish being removed from one of the treated ponds (at Edzell). The most recently treated water body (at Ballachulish) built on the experiences gained and used the site as a training opportunity for fishery trust biologists and staff from SEPA and SNH. The site was treated in 2011 and post-treatment monitoring (Lochaber Fisheries Trust, 2013, 2014, 2015) indicates that this eradication has been successful. A further year of monitoring is required to confirm that this is the case.

Containment

Although eradication may not be possible in rivers and streams, the SAF project considered a wide range of alternative means of signal crayfish control. Preventing the movement of signal crayfish from the Upper Clyde catchment to the catchment of the upper Annan (where the two are separated only by a series of field drains and flooded...
ditches) became a clear priority. A partnership between SNH, the Clyde River Foundation, Annan Fisheries Trust and South Lanarkshire Council led to the design and installation of a ‘crayfish barrier’ in 2011 (Fig. 5). This was the first crayfish barrier installed within the UK and the only design of its type anywhere. The areas upstream and downstream of the barrier are monitored annually by the fishery trusts and the integrity of the barrier is checked annually by South Lanarkshire Council.

Despite the high level of publicity given to signal crayfish, their impact and the need to prevent further introductions, new populations continue to be discovered (Fig. 6). Unfortunately, the majority of signal crayfish records come from rivers and streams where eradication is not possible and containment options are limited.

![New signal crayfish records 1995-present](image)

**Fig 6.** New records of signal crayfish have been recorded by SNH and other public bodies, such as Marine Scotland and SEPA, in most years since 1995. The majority of these (62%) have been reported from rivers and streams. 

Source: SNH

**Problems and solutions**

A key issue at the beginning of the SAF project was the assignment of lead responsibility. This has since been resolved, with SEPA taking the lead in 2012 for halting the spread of signal crayfish to new water bodies. The role of education and awareness in this has also been important. Signal crayfish received considerable media attention during and after the SAF project. This was augmented by the design and distribution of awareness materials, giving presentations and leading seminars for key user groups (such as anglers and affected communities) and running training events. There is no evidence to suggest that heightened awareness has led to a decrease in the rate of new introductions, but many of the ‘new’ records are of established populations that may have been in place for many years.

It remains an unpalatable fact that the options for eradication and control of this species are limited, both in terms of the techniques available and the types of habitat that are treatable. The development of an effective biocide protocol provides some hope that, in some places (such as ponds and small lochs and reservoirs) eradication is a possible, although costly, solution.

The inability to eradicate signal crayfish from many of the locations in which they have been reported has drawn criticism from those who wish to see them removed, and in one site (Loch Ken) this has led to pressure to establish a commercial fishery for this species. This has so far been resisted because the establishment of a fishery may lead to an increased rate of deliberate spread to new waters, as has been shown in other European countries. In response to a petition in support of the development of a crayfish fishery at Loch Ken, the Parliamentary Petitions Committee concluded that there was scientific consensus that allowing the commercial trapping of signal crayfish, even as a control measure, would be likely to lead to the expansion of its range.

The problems of signal crayfish are not restricted to Scotland, but are replicated in other parts of the UK and mainland Europe. An increased culture of collaboration is developing between statutory agencies in the UK, largely through the leadership of the GB Non-Native Species Secretariat (NNSS) and the development of a Crayfish Invasive Species Action Plan. This new approach should improve the coordination of research on signal crayfish within the UK. It is clear, however, that there is no clear solution on the horizon, and that control rather than eradication may, in most circumstances, be the only realistic option.
Lessons Learnt, Further Work and Future Recommendations

Species lead
It is essential that there is a clear lead when dealing with invasive non-native species. One of the basic requirements of their control is the capacity to implement action quickly. This can only be achieved if roles are carefully allocated, and those given responsibility are also given the resources and authority for action.

Partnership working
Dealing with signal crayfish requires close partnership with relevant stakeholders and the public. There is a clear role for a ‘citizen science’ approach to surveillance, and many of the records provided since 1995 have come from the public and the angling sector. The SNH lead for this project was able to obtain support from and co-ordinate the efforts of others, including representatives from Government agencies, academia and the fisheries management sector. This encouraged a sense of ownership of the problem and led to productive action on the ground. However, the period covered by the SAF project (five years) was not long enough to complete all of the necessary actions (such as long-term monitoring of sites treated with biocide) and follow-up resources were not immediately available to continue the work. A dedicated funding stream for crayfish monitoring and rapid assessment would allow the responsible authority to respond to new sightings and identify the potential for control (or eradication) measures.

New and ongoing work since SAF ended
• Invasive Species Action Plan – an action plan, led by the GB NNSS, has been produced for signal crayfish and other crayfish species. The primary aim of this plan is to contain or slow the spread of currently known populations, and mitigate further impact. The measurable outcomes of the plan are that: 1) Government funded non-native crayfish work is coherent, strategic and effective; 2) Biosecurity is improved in high priority areas; and 3) Non-native crayfish populations are contained where possible and rate of spread is slowed.
• A new lead authority – In line with the Framework of Responsibilities developed under section 14C of the Wildlife and Countryside Act 1981 as amended for Scotland in 2012, SEPA is now the lead authority for aquatic non-native species, including crayfish. SEPA also maintains the Crayfish Distribution Database.

Key Management Messages
• Awareness and prevention are key elements of invasive species control, and it is important to emphasise that introductions can lead to permanent, adverse, changes in the ecology of fresh waters.
• A partnership approach is required if the signal crayfish issue is to be managed appropriately, and clear lines of communication between appropriate agencies within Scotland, and between those in Scotland and other parts of the UK, must be maintained.
• Control and eradication, where possible, is likely to be expensive, but changes to the Wildlife & Countryside Act in 2012 mean that these costs may be borne by the person who has illegally introduced this animal to a water body.
• Conventional eradication measures for signal crayfish, such as trapping, are ineffective, and the uncontrolled use of traps is likely to result in the spread of this species to new areas. The maintenance of strict licensing controls and improved surveillance for illegal harvesting activity are essential.
A new EU Regulation – Regulation 1143/2014 on invasive alien species came into force in January 2015. This places restrictions on the keeping, sale and use of signal crayfish and several other species of non-native crayfish. It also places an obligation on Member States to establish a surveillance system for invasive alien species of Union concern, which collects and records data on the occurrence of invasive alien species by survey, monitoring or other procedures to prevent their spread into or within the Union.

Conclusions

• The SAF signal crayfish project has been very successful in raising awareness among those individuals who manage water bodies or fisheries in Scotland.

• Lack of ownership of the problem, and the prospect of long-term, and costly, management action led to difficulties in forming a coherent national partnership.

• The project greatly enhanced our knowledge of the biology and ecological impact of signal crayfish. This allowed the development of management action on the ground, but also highlighted the difficulties that crayfish management poses to those charged with protecting these environments.

• The Crayfish Invasive Species Action Plan offers a real opportunity to set a precedent for managing invasive crayfish species comprehensively, but this will require strategic leadership and immediate action.

Further Information


References


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Monitoring 2013. Report to Highland Council, SNH and SEPA.


Acknowledgements

The implementation of this project relied on the contribution and co-operation of many individuals and organisations. The University of Glasgow (Scottish Centre for Ecology and the Natural Environment), the Clyde River Foundation and SEPA provided partnership funding for the PhD studies of Zara Gladman. The collection of samples, and much of the fieldwork, was facilitated by the CRF and Matt Mitchell of the United Clyde Anglers Protective Association Ltd. Stephanie Peay, Jonathan Brickland and Chris Horill delivered crayfish training courses and awareness events. Callum Sinclair also provided valuable support in mobilising various fishery trusts during the survey and mapping phase of the work. David Molloy, Nick Chisholm (River Annan Trust) and the Clyde River Foundation were instrumental in the design and installation of the crayfish barrier.

The SAF Partners

- Scottish Natural Heritage
- Scottish Environment Protection Agency
- Rivers and Fisheries Trusts of Scotland
- University of Glasgow
- University of Stirling (Institute of Aquaculture)
- Clyde River Foundation
- United Clyde Anglers Protective Association Ltd

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

New Zealand Pygmyweed

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Summary

- New Zealand pygmyweed (*Crassula helmsii*) is an invasive, non-native, aquatic plant species, which tolerates a wide range of conditions of substrate and water chemistry and can survive periods of desiccation. It is also able to regenerate from very small fragments. These characteristics mean that New Zealand pygmyweed represents a considerable threat to the native plant community in sites where it is introduced.
- A training manual was produced to assist with the identification and recording of New Zealand pygmyweed.
- All records of New Zealand pygmyweed in Scotland were collated and the risk posed by existing populations assessed. As a result, management at Mochrum Lochs Site of Special Scientific Interest (SSSI) was agreed as a priority.
- Shading material was used to treat areas of Mochrum Loch that were infested with New Zealand pygmyweed. Limited applications of herbicide were also used.
- Initially, treatment was highly successful, achieving a 96% reduction in the area covered by this species. Subsequent management effort was adequate for control, rather than eradication. There continues to be a need for treatment.
- No New Zealand pygmyweed was recorded in the other lochs of the SSSI for the duration of the project suggesting that it had not spread to these nearby water bodies.

Introduction

New Zealand pygmyweed (*Crassula helmsii*) is an invasive, non-native, aquatic plant species, which grows in ponds, lakes and wetlands. It is found in conditions ranging from nutrient-poor and acidic, to eutrophic or calcareous (Preston and Croft, 1997). The species is a monoecious perennial (Preston and Croft, 1997), which regenerates from small fragments, establishes and spreads rapidly. It tolerates periods of desiccation, so is competitive within the drawdown zone of standing water bodies. It also does not die-back in winter, so it can take immediate advantage of improved conditions in spring. Owing to its highly competitive nature and ability to produce dense stands of vegetation, it is believed to be a significant threat to native species of aquatic and riparian vegetation in the sites to which it is introduced (Kemp and Birkinshaw, 2005). Fig. 1 illustrates the invasive nature of this species.

New Zealand pygmyweed is a native of Australia, Tasmania and New Zealand. The timing of its first release to the wild in Britain is unknown, but the species was first sold as a plant for outdoor ponds in 1927 (Preston and Croft, 1997). It appears to have increased most rapidly in its distribution between 1980 and 1990 (Willby, 2008). However, although rate of spread appears to have decreased in recent years, it has been recorded in areas of conservation importance, such as Brown Moss, Swanholme Lakes and Hatchet Pond in England (Kemp and Birkinshaw, 2005). In Scotland, in 2008, it was found that there were 53 records of New Zealand pygmyweed and it was considered likely that 45-50 of these populations remained extant at that time (Willby, 2008).

As New Zealand pygmyweed is a threat to biodiversity and may spread from sites to which it is introduced, it was included in the Species Action Framework (SAF) (SNH, 2007) as a means to implementing management.
Aims

Aims for 2007-2012
The objectives of the SAF project plan for this species were to:

• Raise awareness about New Zealand pygmyweed.
• Assess the risk to native freshwater species from existing populations of New Zealand pygmyweed.
• Attempt to eradicate the species from a site at which it had become established.

Management Action

Summary of the main action undertaken

Five partner organisations with an interest in limiting the spread of New Zealand pygmyweed became involved in the SAF project: Plantlife, Royal Botanic Garden Edinburgh, Scottish Natural Heritage (SNH), Scottish Environment Protection Agency (SEPA) and Scottish Water. Following discussions between the partner organisations, consultants were engaged to undertake the following actions:

• A training manual to raise awareness about New Zealand pygmyweed and other aquatic, invasive, non-native species was produced by Scott Wilson, to encourage staff of partner organisations to record presence of New Zealand pygmyweed during routine field-work.

• Information on the distribution of New Zealand pygmyweed in Scotland was collated by the University of Stirling (Willby, 2008). For each population, the likely means of colonisation was considered. Potential for spread within and between habitats, and the threat to protected sites or species were then assessed. Fifty-three populations of New Zealand pygmyweed had been recorded in Scotland, of which about 90% were extant. 70% of populations were considered moderately or highly likely to have resulted from direct introduction, and most frequently the species had been observed in small, created or disturbed ponds. 80% of populations were considered to carry a low, or low to moderate, risk. However, in a number of situations, risk should be regarded as moderate or moderate to high. Locations to which this applies include Mochrum Loch, Duddingston Loch, River Tay and Murton.

• Management of New Zealand pygmyweed was carried out at Mochrum Loch, Dumfries and Galloway, by Ecus (2013a, 2013b, 2013c, in prep a, in prep b, in prep c). The measures undertaken at Mochrum Loch are described below.

Location of work

Mochrum Lochs is designated as a Special Area of Conservation (SAC) because of the international importance of its bog habitats. Mochrum Lochs SSSI is of national importance for its standing waters and associated aquatic ecology. Breeding birds and blanket bog are also included as protected features under the SSSI. The standing water feature of interest includes Mochrum Loch, Castle Loch and Black Loch, as these water bodies were judged to be the best examples of lowland oligotrophic waters in the area.

New Zealand pygmyweed was first recorded in Mochrum Loch during Site Condition Monitoring (SCM) in 2004, and by September 2007 colonies of the species were recorded as frequently occurring in shallow water.
Methods and techniques

The measures implemented at Mochrum Loch are presented in Table 1.

Table 1: Management measures carried out since the commencement of the programme of control of New Zealand pygmyweed (2007–12) (Ecus, in prep b).

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of shading fabric</td>
<td>March 2008</td>
</tr>
<tr>
<td>Samples taken to test viability of shaded plants</td>
<td>March 2009</td>
</tr>
<tr>
<td>Application of dichlobenil and glyphosate</td>
<td>March and April 2009</td>
</tr>
<tr>
<td>Installation of shading material</td>
<td>March 2010</td>
</tr>
<tr>
<td>Application of dichlobenil and glyphosate</td>
<td>March 2010</td>
</tr>
<tr>
<td>Removal of fabric installed in March 2010</td>
<td>March 2011</td>
</tr>
<tr>
<td>Installation of shading fabric</td>
<td>March 2011</td>
</tr>
<tr>
<td>Application of glyphosate (three applications)</td>
<td>March 2011</td>
</tr>
<tr>
<td>Removal of shading material installed in March 2011</td>
<td>March 2012</td>
</tr>
<tr>
<td>Application of glyphosate (three applications)</td>
<td>March 2012</td>
</tr>
</tbody>
</table>

Removal of New Zealand pygmyweed by hand was not considered, as this is a labour-intensive method, the success of which relies on removal of the entire plant. This may be particularly difficult in a number of types of substrate. The option of mechanical removal using heavy machinery was also rejected, owing to the sensitivity and value of the habitats on the site. Shading was therefore selected as the control measure.

As the present project involved management rather than research, it was essential that the material used would be effective. Jute matting was used to control curly waterweed (Lagarosiphon major) in Lough Corrib in Ireland (Caffrey et. al., 2010). The advantages of using jute are that it is a natural and biodegradable material, so removal from a water body is not necessary following management of invasive plants. However, jute may break down during the period of management, as noted in a trial using jute to control Canadian waterweed (Elodea canadensis) in Loch Libo in Scotland (Bell, 2013). Similarly, as polythene sheeting is damaged relatively easily, this was not selected for use. A more robust, geotextile material was chosen for use at Mochrum Loch (Ecus, 2013a).

As there is generally a presumption against use of herbicide in standing water features, the option to shade New Zealand pygmyweed was chosen in the first instance. However, this species constitutes a high risk to the feature, so herbicide use was retained as an option for localised follow-up treatment. Dichlobenil was licensed for use on submerged plants when the SAF project started, so was used to treat the New Zealand pygmyweed until March 2010, when its use was banned in aquatic environments. Glyphosate remains licensed for use on riparian plants and those with leaves above the water’s surface, and was used during this project.

The geotextile shading material was first installed at Mochrum Loch in February and March 2008 and removed in December 2008 and March 2009. Fig. 2 shows an example of the fabric in place. In spring 2009, targeted herbicide use was undertaken on the remaining New Zealand pygmyweed. Dichlobenil and glyphosate were applied to submerged and edge/emergent plants, respectively. One larger, new area of colonisation was covered with shading material. In March 2010, spot herbicide treatments of dichlobenil and glyphosate were carried out and larger areas of habitat supporting the species were covered with material. When this was removed in March 2011, further fabric was put in place over different areas of pygmyweed coverage. Three glyphosate treatments were also carried out at that time. A further three glyphosate applications were completed in March 2012 and all remaining shading material was removed (Ecus, in prep c).

Fig 2. Weed control fabric in place at Mochrum Loch.
© Ecus Ltd.
The viability of plant material found beneath the shading fabric was tested in an outdoor holding tank containing rainwater and situated in an un-shaded position. Aquatic compost was used to fill seed trays and samples of plant material were spread across the compost. Aquatic conditions were created by suspending seed trays in the tank, at a water depth of 50 cm. Wetland conditions were simulated by ensuring that compost was saturated with water, but not submerged. The top of the tank was covered with bird netting to prevent spread of New Zealand pygmyweed from the tank. The plant material was left in these conditions for three months.

**Problems and solutions**

**Installation of the fabric**

New Zealand pygmyweed plants break into fragments easily, but submerging shading material slowly minimised the potential for this to occur (Ecus, 2013a). Initially, corners of fabric were weighted with stones, to aid sinking of the material and to hold it in place, but billowing occurred, resulting in a greater risk of fabric becoming loose. In moderately soft substrates, pegs were therefore used to secure the edges of fabric, particularly around the strandline (Ecus, 2013a). However, large stones were also required to keep the fabric in place. In places where the substrate was too soft or hard to use pegs, it was necessary to continue to use stones (Ecus, 2013b).

The fabric used originally was 2.5 m wide, so multiple sheets were required to cover larger areas of infestation. However, separation or drift of layers could occur if sections were not fixed, and New Zealand pygmyweed was found growing between sheets of material. To address these issues, sections of fabric were sewn together. This was found to be labour-intensive and constituted a health and safety risk, because of the prolonged nature of the task in adverse weather conditions. Fabric of 3.5 m width was therefore introduced as an option (Ecus, 2013a). In addition, lengths of fabric were laid to overlap by 0.5 m and to extend beyond the limit of pygmyweed colonisation by approximately 0.5 m. Stones were laid end-to-end around the perimeter of the fabric and along the joins, to prevent light reaching the vegetation below (Ecus, 2013b).

**Properties of the fabric**

New Zealand pygmyweed was found growing along the shoreward edge of the shading fabric. This species spreads naturally by vegetative fragmentation, so presence of viable fragments would not be unexpected. However, occurrence of the plants further up the shore than previously recorded may have been related to the reduction in the roughness of the surface of the substrate, because of the presence of the fabric (Ecus, 2013b). The solution to this problem is to extend the area covered considerably above the water line, though the feasibility of this depends on the profile of the shoreline and types of existing substrate, in addition to the requirements of the native species present (Ecus, 2013b).

Although geotextile material is relatively robust (Ecus, 2013a), wind and wave action, and abrasion against rocks, put stress on the fabric and caused it to tear. Stones were used to weigh down the middle of lengths of material, to prevent excessive abrasion. Fraying at the edges of the fabric was also found to be a problem, so loose threads on cut edges were removed. Edges were folded under to minimise the risk of further fraying (Ecus, 2013a). Material was not reused because of damage (Ecus, 2013b).

It is recommended that assessment of the condition and repair of shading material is undertaken approximately two months after installation. Material employed in areas that are particularly affected by strong winds and wave action should be checked frequently. As winter storms are likely to cause disturbance and damage, consideration may be given to removing fabric in such locations at the end of autumn. However, shading during winter adds a pressure on New Zealand pygmyweed when it is already experiencing sub-optimal environmental conditions and this approach would be expected to reduce its competitive advantage through early spring growth. In addition, treatment in winter is likely to affect native plants to a lesser extent. For these reasons, shading in winter remains a potential method of treatment.

Continuing disturbance from local user groups may also have subjected the fabric to wear and tear. In future, it is recommended that signs are installed at sites where work is being undertaken to request that people avoid the fabric, and areas frequented by the public should be checked for damage (Ecus, 2013a).
Physical demands of working with geotextile material

Installation of shading material was labour-intensive. Teams of two to six people were required for the work at Mochrum Loch, depending on the extent of individual infestations. Installation teams included personnel in chest waders, who operated in shallower areas, and teams in dry suits, who installed the fabric in deeper areas (Ecus, 2013a). Removal of material was necessary, as it was not biodegradable. Removal was less labour-intensive than installation, but required transferral of numerous large stones and hence teams of at least four people. For health and safety purposes, such teams should include at least one person holding a RYA or equivalent powerboat handling certificate and at least one person equipped with a dry suit.

A high level of wear and tear on clothing and equipment was associated with undertaking the work at Mochrum Loch. Over a two-week period, neoprene waders, gloves, dry suits and boat propellers required replacement or repair (Ecus, 2013a). This was due to the rockiness of the site and cold and windy weather. Neoprene gloves and waders with protective finger, palm and knee patches were used rather than more durable equipment options, as neoprene was the most flexible, comfortable and warmest material for working all day in water. Work involved weighting shading fabric with rocks and kneeling on rocky substrates. Although the engine prop was adjustable, the number and distribution of rocks in shallow water were such that scrapes were inevitable. Use of a boat reduced the need for carrying heavy items over rough ground and while wading. Rapid wear and tear of equipment had not been experienced by the workers at other sites where substrates were softer and pegs or bricks were used to secure fabric.

Disposal of shading fabric and attached fragments of New Zealand pygmyweed

Following removal of fabric, fragments of New Zealand pygmyweed were picked from the material and treated with herbicide along with the plants that were still growing. However, it was possible that small fragments may have remained on the fabric. Disposal of used fabric was undertaken through a local waste management company. A single skip was required to remove the material to a SEPA-registered landfill site. A Controlled Waste Transfer Note was provided by the waste management company to ensure a safe and traceable disposal route for the fabric.

Use of herbicide

Covering many small areas with shading fabric was time-consuming and required a greater area of fabric than shading of a single infestation of the same total area (Ecus, 2013b). Herbicide was therefore used for small areas requiring treatment. Use of an adjuvant, such as TopFilm™, in conjunction with glyphosate, is suggested as a way of improving the efficiency of herbicide treatment of New Zealand pygmyweed. From 2010, TopFilm was used with glyphosate in the SAF project. However, trials of the effectiveness of using the adjuvant compared with glyphosate alone in the work at Mochrum Loch were beyond the scope of this management project.

New Zealand pygmyweed is winter-green, so consideration may be given to treating it with herbicide in November or December, thereby minimising potential effects on native plants. It may nevertheless die back to some extent in winter, and treatment in early spring may be less successful owing to poor translocation throughout the plants, low above-ground biomass and problems with live plants being obscured by dead plant material. The condition of the plants should therefore be inspected prior to making a decision on whether to apply herbicide in winter or early spring.

Persistence of New Zealand pygmyweed

Eradication of New Zealand pygmyweed is difficult because fragments of plants from existing areas of colonisation disperse and grow elsewhere within the habitat. Factors such as high winds may exacerbate this problem, encouraging fragmentation and movement of fragments to new locations. There is no known method of mitigating against this, other than to continue to control new areas of growth as they develop. Surveys of the habitat were therefore undertaken throughout the period of management (Ecus, in prep b).

New Zealand pygmyweed is very robust, so shading fabric must be left in place for several months to ensure effective treatment and checking the state of the pygmyweed in a number of locations below the fabric, prior to its removal, is recommended. The number of areas checked will depend on the area of the site and extent of treatment, but 10 areas may be adequate (Ecus, 2013a). Lower stems and roots of the pygmyweed may remain viable after the plant appears to have died, so it is advisable to remove small samples of plant material and to attempt cultivation prior to removal of shading fabric. Alternatively, at least three pieces of fabric of 1 m² may be removed...
and the areas checked for growth of the species one month later. If plants remain viable, treatment should continue (Ecus, 2013a). The effectiveness of shading over different periods of time was not investigated, as resources were limited and the purpose of the project was management rather than research.

In unsubmerged areas, remaining New Zealand pygmyweed may be treated with glyphosate. Alternatively, shading material may be relocated or replaced in remaining areas of infestation. However, combining use of shading fabric with targeted, localised use of herbicide is more likely to achieve control (Ecus, 2013a), so use of both shading and herbicide is recommended. Following removal of the shading material from Mochrum Loch, herbicide treatment of areas of viable pygmyweed was undertaken. Originally, where vegetation was within the area of shoreline subject to wave action, both glyphosate and dichlobenil were used (Ecus, 2013b). However, as dichlobenil is no longer licensed for use in submerged habitats, this is no longer an option.

Over-estimating area requiring treatment

New Zealand pygmyweed spreads rapidly and there is a requirement for a considerable degree of overlap of sections of shading material. During each phase of management, over-estimating the area of habitat occupied by the species ensured sufficient fabric and herbicide would be prepared to undertake management of all areas of colonisation adequately.

Results

Effectiveness of measures

The total coverage of habitat by New Zealand pygmyweed during each survey is recorded in Table 2.

The initial management was highly successful, with coverage by New Zealand pygmyweed decreasing from approximately 10,000 m$^2$ to 359 m$^2$ in March 2009. In September 2010, measured coverage was 268 m$^2$. Coverage then fluctuated and in September/October 2011, it was determined as 646 m$^2$ (Ecus, in prep c). Following the initial work, the level of management effort was therefore sufficient for control, rather than eradication.

New Zealand pygmyweed material taken from areas that had been shaded was found to be unviable, indicating that shading had treated this species effectively. Shading the pygmyweed for at least six months appears to be an effective control measure and use of shading greatly reduces the requirement for herbicide. Fig. 3 illustrates the effect of shading.

The failure to eradicate New Zealand pygmyweed is likely to have been related to a number of factors. Fragmentation of the plants results in continual distribution and development of new areas of colonisation by this species. As there are difficulties with finding and treating small areas of colonisation, the pygmyweed continues to spread within its new locations. The available level of management effort was also limited.

Table 2: Area of habitat of Mochrum Loch covered by New Zealand pygmyweed (Ecus, in prep b).

<table>
<thead>
<tr>
<th>Date</th>
<th>September 2007</th>
<th>March 2009</th>
<th>September 2009</th>
<th>September 2010</th>
<th>March 2011</th>
<th>September 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (m$^2$)</td>
<td>10,000</td>
<td>359</td>
<td>516</td>
<td>268</td>
<td>202</td>
<td>646</td>
</tr>
<tr>
<td>% Decrease</td>
<td>0</td>
<td>96</td>
<td>85</td>
<td>97</td>
<td>98</td>
<td>94</td>
</tr>
</tbody>
</table>
seeds or vegetative means of propagation remains within the treated area, and or/healthy specimens of native species remain elsewhere within a lake, native plant communities will regenerate in treated areas. Fig. 4 shows an area of Mochrum Loch where native plants species are growing following removal of shading fabric.

Fig 4. Regeneration of native plant species following shading. © Ecus Ltd

One of the purposes of management of New Zealand pygmyweed at Mochrum Loch was to reduce the risk of spread of this species to adjacent water bodies and no plants of this species were recorded in Castle Loch and Black Loch for the duration of the project (Ecus, in prep b). Although this may have been the outcome had no control been undertaken in Mochrum Loch, it is logical to conclude that the fewer New Zealand pygmyweed plants there are in Mochrum Loch, the lower the risk would be of spread to other habitats.

A number of measures were implemented to limit the risk of spread of New Zealand pygmyweed through the actions of the SAF project. Surveys were carried out without the use of a grapnel. When removing the geotextile fabric from treated areas, pygmyweed present on the fabric was removed and placed on top of other pygmyweed plants growing in areas above the zone of wave action, and treated with herbicide. Similarly, clothing and equipment were checked before leaving the site. Areas that had been shaded were resurveyed and localised herbicide treatment was carried out where the pygmyweed persisted following shading.

During earlier surveys of New Zealand pygmyweed at Mochrum Loch, a number of larger areas of colonisation were recorded. By 2010, only five areas of more than 5 m² remained, with the largest covering 15 m². New Zealand pygmyweed was found occupying many small areas throughout the habitat. However, by September/October 2011, there had been an increase in the number of areas greater than 5 m² colonised by the species due to unmanaged expansion and the maximum area of coverage had increased to 24 m² (Ecus, in prep b).

Factors affecting management

Shading was found to be highly effective, clearing large areas of New Zealand pygmyweed, which were then available for colonisation by native species. Although using herbicide is considered likely to have been more effective than no treatment, it did not appear to be as effective as expected (Ecus, in prep b). A number of factors may have contributed to this.

New Zealand pygmyweed plants were growing within stands of native species such as the moss *Fontinalis antipyretica* and under dead plant material. In addition, new plants are extremely small. It is therefore likely that some plants were not recorded, so were not treated and in areas where spraying was undertaken, dead material may have provided a barrier to uptake. In addition, if above-ground biomass of New Zealand pygmyweed plants remained limited at the time of herbicide treatment, uptake may have been restricted (Ecus, in prep b). Removal of dead plant material may carry the risk of further fragmentation of New Zealand pygmyweed. An alternative approach may be to undertake more herbicide treatment in late autumn or early winter, before full plant die-back. Weakening the plants before more severe winter conditions occur may help to kill them.

It is not possible to compare the degree to which New Zealand pygmyweed and native plant species were adversely affected by factors other than the two types of treatment, such as extremely low temperatures and changing water levels, which occurred during the course of the project. Cold winter weather may have hindered the growth of the pygmyweed, but is also likely to have restricted the growth of native species. Changing water levels may have given the pygmyweed a competitive advantage over native species, because it can grow in submerged or wetland habitats. Factors in the spring of 2011 which may have encouraged growth of New Zealand pygmyweed despite treatment were warm, sunny weather and low water levels (Ecus, in prep b).
Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

As with many invasive plant species, the complete eradication of New Zealand pygmyweed from a site is likely to be a difficult process and only possible over the course of a number of growing seasons. Continuing monitoring and control is likely to be required over several years.

There were a number of issues with the work to control New Zealand pygmyweed at Mochrum Loch. In the first instance, the length of time between the record being made and measures being taken was three years, because no individual or organisation had a clear responsibility for dealing with it. As this plant spreads quickly, it is important that management is implemented rapidly if eradication is to be a likely outcome. There is therefore a need for clearly defined roles and responsibilities, in addition to rapid response protocols describing actions that are required and identifying who would implement them.

In order to reduce the delay in implementing measures further, an action plan is required, so that a management team can be mobilised quickly. There is a requirement for dedicated personnel and adequate funding for such work. It became evident that the effort it was possible to put into this project was adequate for control rather than eradication of New Zealand pygmyweed. Continued effort at this level would mean long-term intervention. Although less expensive in the short-term, long-term, indefinite intervention would be costly. In future, a potential alternative approach of mobilising many volunteers under the direction of a project officer may be an option. This type of approach has been implemented for management of New Zealand pygmyweed at Loch Flemington. However, the source of resources for carrying out the work at Mochrum Loch in the long-term is uncertain.

Eradication of New Zealand pygmyweed is difficult because fragmentation of existing plants leads to proliferation of new plants. By the end of the SAF project, New Zealand pygmyweed was supported by a relatively small area of habitat at Mochrum Loch, but because of fragmentation was present in a large number of small patches, rather than a small number of large patches. This makes it more difficult to find and to manage. Repeated, thorough surveys will be required as part of any future work (Ecus, in prep b).

Management of New Zealand pygmyweed in submerged habitats is problematical, owing to the greater difficulty of observing all plants and the logistics of applying treatments. In addition, no herbicide is now licensed for use on submerged plants. This is a significant loss when considering the treatment of small areas of infestation. A potential solution to this problem in certain lochs would be to lower the water level and apply

Key Management Messages

• Management of New Zealand pygmyweed should start immediately after its discovery within a site, to optimise the potential for eradication.
• Shading is an effective method of managing this species and allows recovery of native plants following treatment.
• Limited, focused use of herbicide may be necessary following the use of shading material on larger areas of colonisation, as the logistics of shading many small areas of colonisation may be difficult. However no herbicide is currently licensed for use in submerged environments.
• Following management, it is necessary to continue to monitor the site for further growth of New Zealand pygmyweed within the treated area and in potential new areas of colonisation.
• Following establishment of New Zealand pygmyweed at any individual site, unless the area of colonisation is small and/or localised, substantial resources will be necessary to allow effective management.
glyphosate to exposed areas (Ecus, 2013b). However, the feasibility of this option would depend on whether there is infrastructure for managing water levels and on the potential effects of drawdown on the ecology of the water body and the river downstream.

Further Information


References


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The SAF Partners

- Plantlife Scotland
- Royal Botanic Garden Edinburgh
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- Scottish Water
The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

Rhododendron ponticum
and its invasive hybrids

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Summary

- Invasive hybrids of *Rhododendron ponticum* are widespread in Scotland, especially in the west, and are a threat to native woodland and other habitats, and to many of their characteristic species.
- Survey and rhododendron control were carried out on several sites designated for their valuable woodland, in Argyll and Bute and in Highland.
- Greater understanding has been gained of the barriers to control of rhododendron in Scotland, especially the limitations of the financial support available through the previous Scotland Rural Development Programme (SRDP).
- Recommendations are made for improving the planning, resourcing and management of rhododendron control. In particular, it is advised that management is coordinated across ownership boundaries, in order to control entire populations of rhododendron and avoid the risks of re-colonisation from neighbouring land.
- Forestry Commission Scotland (FCS) is implementing a strategy to eradicate rhododendron from the National Forest Estate (NFE).
- A strategy is being developed for control of rhododendron in Scotland.

Introduction

Species background

*Rhododendron ponticum* (and its invasive hybrids) (also referred to as ‘rhododendron’ in this chapter) is a non-native small tree or large shrub that is common in parks and gardens but has spread into woodland, open moorland and other habitats, where it has become a pest species.

Why was this species on the Species Action Framework list?

This species met criterion 2 of the Species Action Framework (SAF) as an invasive non-native species that presents a great risk to biodiversity (Scottish Natural Heritage, 2007).

Habitat, distribution and abundance

It is widespread and locally abundant in woodlands and associated open habitats throughout Scotland, where its deep shade has led to a serious decline in the abundance and diversity of the characteristic native plant communities (see below for more detail). About 75 designated features are in unfavourable condition because of rhododendron, including more than 40 woodlands, and 19 sites with important lichen or bryophyte assemblages. It spreads rapidly by seed, and regenerates from small fragments of material. It is essential that control is coordinated across ownership and administrative boundaries, and that follow-up action is sustained to prevent recolonisation of cleared ground. Although it is difficult to control, there are effective management options available. Removal of this invasive shrub can have a beneficial effect on many species, including mosses, liverworts, lichens and birds.

History of invasion and expansion

The true *R. ponticum* was first introduced from south-west Spain in 1763. Subsequent introductions have also occurred, some from the Pontic region, although genetic evidence suggests that British plants are entirely Iberian in origin (Milne and Abbott, 2000). It is important to note that there are over 1000 species of *Rhododendron* altogether, many of which are grown in gardens or botanic gardens and are not invasive in Scotland.

Imported plants have since been crossed with other species, most notably the North American *R. catawbiense* and *R. maximum*. The level of such mixing is much greater in eastern Scotland and it is suggested that this may confer greater cold tolerance, allowing it to colonise colder parts of Britain (Milne and Abbott, 2000). As hybridisation is common in *Rhododendron* species, it is also possible that interbreeding from some of the 500 other species cultivated in Britain has occurred through accidental or deliberate crossing in cultivation. The resulting invasive British plant is a stable hybrid, which acts as a distinct species – the name *R. x superponticum* has recently been proposed (Cullen, 2011).
Rhododendron ponticum was known in the wild by at least 1894 and spread widely in the 20th century (Preston et al., 2002). The rate of spread has accelerated in the last 50 years, possibly as a result of increased disturbance to natural communities from forestry, the impact of myxomatosis on rabbits, and over-grazing (Rotherham, 2003). Its distribution is now considered stable by some, in that it has not been detected in new 10-km squares, but the species is still expanding aggressively within individual patches of habitat.

Impacts on other biodiversity and conservation interests

Rhododendron ponticum colonises new habitat – especially woodland and heathland – quite rapidly, and can regenerate via seeds, suckers or rootlets. It forms extensive dense thickets which cast a very deep shade, leading in woodland to loss of ground flora, epiphytic bryophytes and lichens, modifying the fauna and preventing regeneration of trees. In addition to the effect of shade, it may produce biochemicals that can affect other plants, inhibiting the germination or seedling establishment of other species. There is also evidence for the prevention of mycorrhizal development in the roots of seedlings of competing plant species. R. ponticum may act as an intermediate host for Phytophthora ramorum, which in Scotland primarily affects larch and can also affect blaeberry (Vaccinium myrtillus).

The Scottish Code of Practice on Non-Native Species identifies the extensive growth of invasive hybrids of R. ponticum in the west and south-west of Scotland as a major threat to biodiversity of international importance, particularly mosses, liverworts and lichens.

Aims

Aims and objectives for 2007-2012

The main objectives for the implementation plan over this period were to:

• Develop a list of priority sites and calculate the costs of rhododendron eradication to inform future work and bids for funding.
• Implement clearance and appropriate follow-up treatment on Natura sites (designated under the Habitats or Birds Directive because of their value for species or habitats of European importance) and surrounding areas.
• Organise training and demonstration sites to ensure that site management staff and contractors have the necessary skills to implement management.
• Develop research into the management of vegetation to inhibit seed germination and re-establishment of rhododendron following clearance.
• Encourage the replacement of R. ponticum and its invasive hybrids with non-invasive rhododendrons in gardens and designed landscapes.

Management Action

Work was focused on two projects, the Argyll, Loch Lomond and Trossachs Rhododendron Partnership (2008-2011) and the Highland Rhododendron Project (2010-2013). Over five years they concentrated on stimulating rhododendron control on those designated sites in unfavourable condition where additional support was most likely to have a positive impact. Funding for such work was available through the Scotland Rural Development Programme (SRDP). Where necessary, these projects were able to fund survey of priority sites to inform the development of control programmes, as SRDP could not fund such work.

In parallel, Forest Enterprise Scotland (FES) launched an ambitious strategy to control rhododendron on the National Forest Estate across the whole of Scotland.

Argyll and Bute/ Loch Lomond and the Trossachs National Park Rhododendron Project

Aim

To carry out work required to achieve the aims of the respective rhododendron strategies in Argyll and Bute, and Loch Lomond and the Trossachs National Park (LLTNP).
**Location of work**

The project area covered the overlapping areas of Argyll and Bute and the LLTNP. Strategic assessments, which set priorities for targeted rhododendron control, had been carried out for both areas.

**Methods and techniques**

The Project Officer worked with owners and managers to stimulate uptake of SRDP in order to tackle rhododendron spread, and to identify problems preventing land managers from controlling rhododendron.

**Problems and solutions**

There are many reasons why land managers may not wish, or be able, to control rhododendron. These include:

- Issues relating to SRDP. Standard costs were increased following a review of support carried out by the Project Officer. Further suggestions for improvement of support are given in the next section.
- Lack of social incentive – there is no pressure on landowners to act. Species Control Agreements under the provisions of the Wildlife and Countryside Act 1981 (as amended) are likely to be useful here, especially in cases where neighbouring land managers are carrying out control work which is threatened by an uncontrolled population nearby.
- Some owners like rhododendron for its flowers, or for shelter or privacy. In some cases, the offer of replacement with non-invasive rhododendron or other species may help to encourage control of *R. ponticum*.

**Partnership working and resourcing**

The Project Officer was employed by FCS, and jointly funded by FCS, SNH and the LLTNP. The principal source of funding for rhododendron control was SRDP.

**Results**

A Rhododendron Project Officer for the area was appointed in October 2008 and continued until summer 2011.

In 2008/09, between the closure of the Scottish Forestry Grant Scheme and the launch of SRDP, the SAF project was able to directly fund rhododendron clearance from designated sites in unfavourable condition where:

- work needed to be carried out urgently to stop the problem getting worse and/or to ensure the value of other work already carried out or in progress.

Work took place on three sites: Craighouse Ravine SSSI, Coille Leitire SSSI (part of Loch Etive Woods SAC) and Ardura - Auchnacraig SSSI (part of Mull Oakwoods SAC).

The Project Officer carried out a review of support available through SRDP, which led to the introduction of improved standard costs for rhododendron clearance in 2010.

Following this, the Project Officer produced *Rhododendron in Argyll and Bute and Loch Lomond and the Trossachs National Park: a strategy for its control* (Murphy, 2010) to guide those preparing, or assessing, applications for support for rhododendron control. Further guidance included a management plan for Ardkinglas on Loch Fyne, which was intended as a template for other sites.

SRDP is now funding the removal of 56 ha of rhododendron over four sites. In addition, SNH is funding rhododendron control through management agreements on Ardpattern and Dunmore Woods SSSI and Tarbert to Skipness Coast SSSI (both within Tarbert Woods SAC) and Eilean na Muice Duibhe SSSI/SAC.

**Highland Rhododendron Project (HRP)**

**Aim**

The HRP was initiated to engage with the private sector, in order to encourage and develop applications to SRDP to tackle invasive rhododendron, in and adjacent to key designated sites in Highland.

**Location of work**

It was agreed that HRP should focus on those designated sites in unfavourable condition where additional input from HRP was most likely to have a positive impact. Twenty-three designated sites were identified as top priorities.

The Highland Rhododendron Control Strategy, published by HRP in 2011, sets out criteria for identifying priority control areas, where ‘actual costs’ were available through SRDP for treating privately owned sites.
Methods and techniques

HRP worked with owners and managers in priority areas to stimulate uptake of SRDP to tackle rhododendron spread. Initially, the Project Officer concentrated on understanding their attitudes to rhododendron and its management, discussing their willingness to clear rhododendron, and what factors might present barriers to such work. The project then sought to investigate ways of overcoming these barriers in order to encourage and enable land managers to carry out rhododendron control.

Problems and solutions

Uptake of SRDP was slow, although it increased after improvements to standard costs, publication of the Highland Rhododendron Control Strategy, and provision of SAF project funding for survey work to enable production of management plans. However, SRDP was not an effective means of funding rhododendron control; further details and suggestions for improvements are given in the next section.

Partnership working and resourcing

The HRP was jointly funded by SNH, FCS and the Highland Council, together with Highland Birchwoods, who employed the Project Officer. The principal source of funding for rhododendron control was SRDP. Some money was available from SAF for additional work that could not be funded through SRDP.

Results

- Between June 2010 and September 2012, 14 Statements of Intent (SOI) were submitted to the SRDP as a result of HRP activity (Fig. 1).
- Rhododendron survey was carried out on 16 sites to inform production of management plans (Table 1).
- In order to trial the concept of coordinated landscape-scale control, the HRP sought tenders for the coordination of rhododendron control within four landscape management zones. Unfortunately the response was poor and no contracts were awarded.
- The HRP organised two stem-treatment training events and field demonstrations of the technique.

- The development of Lever and Mulch™ control technique through:
  - Organising three training events and developing detailed training packs.
  - Establishing a demonstration site at Fairburn Estate, Ross-shire.
  - Securing agreement with Highland Conservancy that small-scale proposals using this technique would be supported. Subsequent to this, the technique was formally included within the rhododendron control option.

Table 1. Rhododendron surveys carried out using SAF funding

<table>
<thead>
<tr>
<th>Site</th>
<th>Estate</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land adjacent to Beinn Dearg SAC</td>
<td>Braemore Estate</td>
<td></td>
</tr>
<tr>
<td>Cawdor Woods SAC</td>
<td>Cawdor Estate</td>
<td>28</td>
</tr>
<tr>
<td>Corrieshalloch Gorge SSSI</td>
<td>Inverbroom Estate</td>
<td>3</td>
</tr>
<tr>
<td>Drimnin to Killundine Woods SSSI</td>
<td>Drimnin Estate Kildunnie Estate</td>
<td>1,000</td>
</tr>
<tr>
<td>Dundonnell Woods SSSI</td>
<td>Eilean Darrach Estates</td>
<td>140</td>
</tr>
<tr>
<td>East Lochaber Landscape Management Zone (LMZ)</td>
<td>Coruinan Estate</td>
<td>50</td>
</tr>
<tr>
<td>Glen Beasdale SAC</td>
<td>Arisaig House Arisaig Farm</td>
<td>25</td>
</tr>
<tr>
<td>Kinloch &amp; Kyleakin Hills SAC</td>
<td>Grace, Duisdale House Hartley, Duisdale MacDonald, Duisdale</td>
<td>22</td>
</tr>
<tr>
<td>Loch Moidart and Loch Shiel Woods SAC</td>
<td>Brunery Woods Kinlochmoidart Estate Glenmoidart Estate</td>
<td>355</td>
</tr>
<tr>
<td>Loch Morar SSSI</td>
<td>Nevis Estate Morar Lodge Estate</td>
<td>407</td>
</tr>
<tr>
<td>Loch Quoich</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Onich – North Ballachulish Woods SAC</td>
<td>Achnacarry Estate</td>
<td>830</td>
</tr>
<tr>
<td>Onich Extension (Cuil Cheanna)</td>
<td></td>
<td>72</td>
</tr>
<tr>
<td>Sunart SAC¹</td>
<td>Carna Island Oransay</td>
<td>100</td>
</tr>
<tr>
<td>Torridon Forest SSSI</td>
<td>Torridon Estate</td>
<td>23</td>
</tr>
<tr>
<td>Land adjacent to NFE treated site in Glencoe and Callert (E. Lochaber LMZ)</td>
<td>Multiple ownerships</td>
<td>11,158</td>
</tr>
</tbody>
</table>

**TOTAL** 14,413

¹ The majority of rhododendron within the Sunart SAC was surveyed by Donald Kennedy (2008).
Lessons Learnt, Further Work and Future Recommendations

The most important lessons have been:

- **SRDP was not an effective support mechanism for rhododendron control, owing to:**
  - The nature of the benefit, which is largely to the public interest rather than to the owner.
  - The short-term nature of SRDP contracts (five years).
  - The complex and costly application process.
  - The inflexibility with regard to control methods (work must be planned in detail beforehand, whereas the most successful control results from adapting techniques to the site).
  - The requirement for management to be financed up front, and then reclaimed, together with the time taken for grant payment.
  - The risk of having grant reclaimed if 100% success is not achieved after five years.

- An approach that relies on individual landowners developing plans independently is unlikely to work, except for relatively small infestations on individual sites. Instead it would be valuable for an organisation or individual to be appointed to work with land managers in order to develop a plan for controlling rhododendron across a defined area, acquire resources to fund the work and manage control work across the area.

- A more persuasive argument for control is needed, based on the value of land cleared (e.g. land affected by rhododendron is not eligible for Single Farm Payment), rather than the damage caused by rhododendron.

- Support is needed for rhododendron control on those small land-holdings and gardens that have not been eligible for SRDP, or where it is not a cost-effective means of support. Such areas can significantly affect the success of control on neighbouring land.

- Better information, guidance and support is needed to help identify the most effective methods of control, and especially to promote less well-known, but highly effective, methods such as stem injection.

- The commitment from FES to eradicate rhododendron from the NFE is proving a useful catalyst for discussing collaborative control with neighbouring landowners. Some of these may have been reluctant to undertake control previously, because of a concern about reinvasion from NFE land.

**New and ongoing work since SAF ended**

Forestry Commission Scotland continues to implement its control strategy on the National Forest Estate and a national strategy for rhododendron control across Scotland is now being prepared. This will be informed by the lessons learnt through SAF, detailed above. The new SRDP opened in March 2015, and Rhododendron control options are available through the Forestry Grant Scheme for wooded land, and the Agri-Environment Climate Scheme for open ground. These are intended to be more flexible than under the previous SRDP, are targeted at the highest priority areas, and support for collaborative applications will be available.

In Argyll, much effort is currently focusing on Glen Creran, which includes land owned by FCS and SNH as well as a private estate, and many small landowners and domestic properties. Gardens are not eligible for SRDP, and for many other small landowners the work required to apply for SRDP funding is too great for it to be worthwhile. The community is working together to develop a plan for rhododendron control within the whole glen, and to obtain funding to carry it out. This is a valuable model for collaborative control of rhododendron, and potentially other invasive non-native species, more widely.

The **Argyll and the Isles Coast and Countryside Trust** is working to co-ordinate a region-wide approach to encouraging, funding and carrying out rhododendron control.

RSPB and Plantlife are preparing a LIFE project to carry out Atlantic Woodland Restoration through rhododendron removal and conservation management, for submission in autumn 2015.

In Highland, work is continuing to improve survey data for priority sites, so that land managers have the information they need to prepare applications for grant funding.
Key Management Messages

- A range of methods are available for controlling rhododendron successfully, and the most appropriate form of management will depend on the characteristics of individual sites, patches and even single bushes. A flexible approach, which uses a range of options, is likely to be most successful.
- For long-term success, it is vital to control rhododendron at the population level, working across management boundaries if necessary. If areas of rhododendron are left unmanaged, reinvansion will occur.
- It is unlikely that complete success will be achieved in a single year with any of the methods available. Follow-up treatment will be required and monitoring, with seedling removal, is likely to be needed for at least ten years.

Further Information

- [http://www.highlandbirchwoods.co.uk/rhododendron.asp](http://www.highlandbirchwoods.co.uk/rhododendron.asp) – information about the Highland Rhododendron Project.
- [https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/forestry-grant-scheme/woodland-improvement-grant/habitats-and-species/](https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/forestry-grant-scheme/woodland-improvement-grant/habitats-and-species/) – Forestry Grant Scheme Woodland Improvement Grant: Habitats and Species.

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The Species Action Framework Handbook

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Wireweed

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Summary

- Wireweed (Sargassum muticum) is large brown alga from the Western Pacific that has been introduced to Europe, where it is an invasive, non-native species posing a significant risk to marine biodiversity, primarily through competition with indigenous marine algae and seagrass species.
- In Scotland it was first recorded from Loch Ryan in 2004, since when it has spread rapidly along the west coast, reaching South Uist by 2013.
- To identify coastal areas where the establishment of wireweed was most likely, as part of the Species Action Framework (SAF) project, an ‘occurrence-pathway’ modelling approach was developed, incorporating factors such as wind and tide direction, wave and current information. Surveys were carried out at locations predicted to be vulnerable to colonisation.
- A public relations campaign was carried out to raise awareness of wireweed and to encourage the reporting of new records to complement the targeted surveys.
- A detailed review of the ecology of wireweed was commissioned in support of the SAF project.
- The SAF surveys indicate that wireweed has spread along a significant part of the western Scottish coast. The Scottish and wider global distribution of wireweed is such that eradication from Scotland is not now possible, and further expansion cannot be prevented.
- Except where it is locally a nuisance, control of wireweed is unlikely to be effective and the species will become part of the Scottish coastal ecosystem.
- Three wider conclusions are drawn:
  1. Non-native species management should be targeted at preventing the introduction of marine non-native species, as once they are established they are very difficult to remove.
  2. Involvement of the public is important in identifying the spread of a species, and in preventing introductions.
  3. Management of marine non-natives needs to be done in collaboration with neighbouring countries.

Introduction

Species background

Wireweed (Sargassum muticum) is an olive-brown alga growing to more than a metre long (Fig. 1). It is native to the western Pacific, but has been introduced to other parts of the world including the eastern Pacific and eastern Atlantic. It was first recorded in the UK in 1973 at the Isle of Wight and has since spread along the south coast of England, to Wales and around Ireland. The first reports of wireweed in Scotland were in Loch Ryan in 2004, since when it has spread rapidly along the west coast. By early 2007 populations had been found at Great Cumbrae Island, the north Ayrshire coast, Arran and at Claonaig on the Mull of Kintyre (Davison, 2009).

Fig 1. Wireweed.
© Lorne Gill/ SNH

Why was this species on the Species Action Framework list?

In Europe, wireweed is an invasive, non-native species which meets criterion 2 of the Species Action Framework (SAF), as posing a significant risk to Scottish marine biodiversity, primarily through competition with indigenous marine algae and seagrass species (Scottish Natural Heritage, 2007).

The ongoing dispersal of wireweed along Scotland’s coastline has implications for the suite of nationally and internationally important marine protected areas established around the Scottish
coast and for waterbodies meeting environmental objectives of good ecological status under the Water Framework Directive.

The arrival of wireweed in Scotland in 2004 provided an opportunity for scientists and conservation managers to study the way that an invasive non-native species has established and spread in Scottish waters, as well as how invasive species can best be managed. Although it was not possible to prevent the further spread of wireweed, lessons could be learned from its arrival to help develop strategies for preventing and controlling future introductions of invasive species. SAF could also be instrumental in raising awareness of the problems associated with non-native species, the importance of preventing their arrival and the difficulties of controlling them once they are here.

Habitat, distribution and abundance

Wireweed usually grows attached to rocky substrates close to the lower shore or in shallow, sub-tidal waters or in mid-shore rock pools (Fig. 2). It is also found on sandy or muddy shores if stones are present to which the plants can attach. Wireweed prefers sheltered habitats as it can be damaged by wave action in more exposed sites.

The natural range of wireweed is thought to be the western Pacific region. It is likely to have been introduced to the eastern Atlantic in the late 1960s or early 1970s. Since then, it has colonised parts of the Atlantic coast from Morocco to Norway and as far west as the Republic of Ireland. In Scotland, at the start of the SAF project, wireweed was known to occur at a few sites in south-west Scotland in Loch Ryan and the Firth of Clyde. The west coast of Scotland was regarded as providing a large extent of potentially suitable habitat for the establishment of wireweed, and since 2007 it has been recorded at several sites as far north as Skye and North Uist.

General ecology

Wireweed plants have long fronds with side branches that hang like washing from a line (Fig. 3). In autumn the branches break off from the basal structure and, owing to their distinctive grape-like air bladders, can be found floating individually or in a large mass. These detached fronds remain reproductively capable and contribute to the species’ ability to spread rapidly. The base of the plant remains attached to the rock and will regenerate new branches in the spring time.

Fig 2. Wireweed in rock pool, Great Cumbrae Island, Firth of Clyde.
© Lorne Gill/SNH

Fig 3. Wireweed has a distinctive appearance with numerous side branches hanging from the main frond.
© SNH
Wireweed can tolerate wide ranges of temperature and salinity. The competitive ability of wireweed may be reduced at lower salinities, for example at the head of sea lochs with a high freshwater input (Steen, 2004). A detailed review of the ecology of wireweed, commissioned in support of the SAF project, can be found in Davison (2009).

History of invasion and current threats

Marine non-native species can be transported around the world either intentionally, for example as live seafood or for aquaria, or accidentally, for example on the hulls of boats or in ballast water (Hewitt et al., 2007). In the case of wireweed, the method of transportation is not known, but it may have been introduced around the world as germlings transported alongside Pacific oysters destined for shellfish farming (Cheang et al., 2010). Transport over short distances may occur if wireweed fronds become entangled in boating equipment, such as anchors, and are then released in a new area. Most marine non-native species in Scottish waters are unlikely to have arrived directly from their native origin (Donnan and Manson, 2010). It is likely that wireweed arrived in Scotland from introduced populations in adjacent waters.

It is a fast-growing species able to form dense stands where conditions suit and is ideally adapted to spread rapidly once established in a new region. Detached fronds can remain reproductively active for several weeks enabling dispersal over a wide area. Wireweed can quickly exploit open spaces that become available and it is considered to be an ‘opportunistic gap-grabber’.

The spread of wireweed, through competition with native algae, can lead to changes in the local habitat and consequently the local fauna (Salvaterra et al., 2013). It has the potential to replace native species, possibly out-competing them for light and substrate (Harries et al., 2007a). The replacement of native species by a non-native species can have a direct impact on the biodiversity of an area by causing a shift in marine communities and their trophic food webs.

Seagrass beds on soft sediments can be colonised by wireweed, with the seagrass appearing to act as a hard substrate for attachment (Tweedley et al., 2008). Attachment to clams living within seagrass beds has also been noted. Once such beds have been colonised there is potential for the wireweed to outcompete the seagrass, therefore greatly altering the habitat as a whole (White and Orr, 2011). As seagrass beds are of high conservation importance, invasion by wireweed is of concern.

In addition to having an ecological impact, wireweed is considered a nuisance in harbours and shallow waters where large floating masses may become a hazard to commercial and recreational boating through entangling in propellers or blocking engine cooling systems. The floating mats can also affect water sports such as swimming, wind surfing and sailing. Wireweed can foul fishing nets and lines and can seriously impact on oyster beds and other aquaculture structures.

Aims

Aims for 2007-2012

- To assess the spread of wireweed and identify its impacts on biodiversity.
- To develop and implement a control strategy to prevent the further spread of wireweed and reduce its impact on native biodiversity.

Action under SAF

At the start of the SAF project the spread of wireweed along the west coast of Scotland as far as the Outer Hebrides was predicted within the ‘next few years’ (Harries et al., 2007b). A review of information, issues and implications was carried out for wireweed to support the SAF project (Davison, 2009). The main focus of the project was then to determine the distribution and spread of wireweed, and to raise awareness.

Mapping the distribution of wireweed

In order to track the spread of wireweed in Scotland, two complementary approaches were used:

- Surveys were carried out at locations predicted to be vulnerable to colonisation.
A public relations campaign was carried out to raise awareness of wireweed and to encourage the reporting of new records.

To identify coastal areas where the establishment of wireweed was most likely, an ‘occurrence-pathway’ modelling approach was developed, incorporating factors such as wind and tide direction, wave and current information (Trendall et al., 2010). The model predicted high risk areas (Fig. 4).

Dedicated surveys between the Solway Firth and the Ardnamurchan peninsula were also commissioned by SNH to establish the extent of wireweed at both the reported sites and predicted sites (Trendall et al., 2010) (Fig. 5). During 2008, the surveys found wireweed to be widely distributed throughout the Firth of Clyde, forming dense stands at some locations. In particular, stands of wireweed were found around the islands of Cumbrae and Arran and along the Ayrshire coast near Largs, Ardrossan, Culzean and Maidens. Outwith the Firth of Clyde, attached plants were found only at West Loch Tarbert. However by autumn 2008, established populations were also reported in Loch Sunart and the Isle of Skye.
Comparing the model with the results of the dedicated survey, the model proved to be a successful tool in predicting the spread of wireweed (Trendall et al., 2010). Many of the predicted sites for wireweed were either confirmed during the field survey or from subsequent reports. Of particular conservation concern is that wireweed was found attached at two Special Areas of Conservation (Luce Bay and Sands, and Sunart). Floating fragments were also found in the Firth of Lorn Special Area of Conservation.

To help record the spread of wireweed over a greater extent than it was possible to survey, a public sightings campaign was launched by SNH. A webpage and telephone reporting service were established. The public campaign resulted in reports of wireweed from as far south as Luce Bay in the Solway Firth to as far north as Loch Sunart in Ardnamurchan and Tarsskavaig on Skye by 2008. Wireweed was found to be widespread throughout the Firth of Clyde. Conducting a dedicated survey over such a large area would have been impractical. The public campaign demonstrated that involving the public is an effective means of extending the scope of dedicated survey.

The combined results of SNH surveys and the public sightings campaign by the end of 2008 are presented in Fig. 6. These results show that wireweed has spread significantly since its first recorded sighting in Scotland in 2004 and is now well established along the coast of western Scotland. A more recent report from 2013 shows that wireweed has reached North Uist in the Western Isles.

The results of the survey and public campaign have been presented as a case study in the SNH publication Species Management: Challenges and Solutions for the 21st Century (Donnan and Manson, 2010).

Publications associated with the SAF project

The following publications are either direct outputs from, or have been informed by, the SAF wireweed project:

- Harries et al. (2007b) – reviews the dispersal and establishment of wireweed and identifies potential new areas in Scotland for colonisation.
- Davison (2009) – provides a review of the main issues associated with wireweed.
- Trendall et al. (2010) – models the spread of wireweed in Scotland and reports on surveys to assess its distribution.
Lessons Learnt, Further Work and Future Recommendations

Options for the control of wireweed in Scotland

It is evident that wireweed is well established along the European coast. The results of the SAF survey indicate that wireweed has also spread along a significant part of the western Scottish coast. Even if wireweed could be controlled locally in Scotland, any large scale control would require international co-operation. It is likely that the Scottish and international distribution of wireweed is such that eradication from Scotland is not now possible. It is also likely that further expansion of wireweed in Scotland cannot be prevented.

Except where it is locally a nuisance, control of wireweed in Scotland is unlikely to be effective and the species is likely to become part of the Scottish coastal ecosystem.

Lessons learnt

The wider conclusions from the project are:

- Non-native species management should be targeted at preventing the introduction of marine non-native species, as once they are established they are very difficult to remove.
- Involvement of the public is important in identifying the spread of a species, and in preventing introductions.
- Management of marine non-natives needs to be done in collaboration with neighbouring countries.

Future recommendations

Including wireweed within the SAF project has helped to raise the profile of marine non-native species. Over a thousand marine non-native species have been identified in European waters (Katsanevakis et al., 2013). Ninety non-native species have been identified in British brackish and marine waters, of which 58 are established (Minchin et al., 2013). Although many marine non-native species are unlikely to have a negative impact, some can cause local shifts in the assemblages of native species (Kelly et al., 2011). Wireweed is one such species. Other, as yet unidentified species could have a highly negative impact upon Scottish coastal ecosystems and the coastal economy.

With regard to wireweed it is recommended that the distribution should continue to be recorded, particularly during the current colonisation of new parts of the Scottish coast. Particular attention should be directed towards Special Areas of Conservation and lagoon systems where wireweed has the potential to have a negative impact upon native biodiversity (Trendall et al., 2010). Relative to other marine non-native species, wireweed has been extensively researched. Research should continue into the longer term impacts on Scottish coastal ecology.

The case study of wireweed has relevance to other marine non-native species including influencing future policy and advice.

Priorities for the future should be to predict, record and, where possible, eradicate new invasive species; as well as to control the further spread of existing marine non-native species. Since the start of the SAF project, Scotland has made significant progress towards meeting these priorities, notably through the work of the Firth of Clyde Forum.

Key Management Messages

- Eradication of wireweed from the Scottish coast is not likely.
- Local control of wireweed is an option where wireweed presents a nuisance.
- It is likely that wireweed will continue to spread into suitable habitats around the Scottish coast.
- Early detection of new marine non-native species is a high priority, requiring international cooperation.
New and on-going work since SAF ended

The following developments have taken place:

• SNH has continued to collate records of wireweed. Sightings can be submitted via the SNH website. Wireweed has been reported from the strandline of a beach in North Uist in August 2013, extending its known Scottish distribution to the north and west.

• The Firth of Clyde Forum produced a Biosecurity Plan for the Firth of Clyde 2012–2016.

• The Firth of Clyde Forum and Scottish Natural Heritage have produced a series of documents on marine biosecurity planning, including: a review of best practice (Cook et al., 2014); guidance for producing site and operation-based plans for preventing the introduction of non-native species (Payne et al., 2014a); and a dissemination strategy and communications plan (Payne et al., 2014b).

• In 2013 SNH, Scottish Government and the Scottish Association for Marine Science (SAMS) trialled an early warning system for non-native species around and off the Scottish coast (Cook et al., 2015).

Further Information


References


**The SAF Partners**

- Heriot-Watt University
- Joint Nature Conservation Committee
- Marine Scotland Science
- Scottish Association of Marine Science
- Scottish Natural Heritage
- Scottish Environment Protection Agency
- University Marine Biological Station Millport

**The Species Action Framework Handbook**

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to [www.snh.gov.uk/speciesactionframework](http://www.snh.gov.uk/speciesactionframework).


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We would like to thank all the members of the public who responded to the request for wireweed sightings. Without their help we would not have been able to chart the distribution of wireweed as effectively.

Several partner organisations listed below helped with the surveys and provided expert opinion on wireweed.
Of all aspects of managing species, those involving direct or indirect conflicts with people are arguably the most difficult to deal with. ‘Conflicts involving native species’ occur mainly when the behaviour of a species brings it into conflict with people’s interests or with the conservation of other species or habitats. Where socio-economic interests are involved, solutions need to be found that ensure the conservation of the species while recognising these interests. Where a species has impacts on habitats or on other species, the conservation of both is considered in finding solutions.

Actions in different cases may include supplementary (diversionary) feeding or scaring to modify the species’ behaviour, local non-lethal or lethal control to reduce the species’ impact on other interests, or efforts aimed at changing the human activity that leads to the conflict, for example through voluntary agreements, public education or codes of practice. The particular actions will depend on the ecological situation and on the conservation needs of the species involved (which may be reflected in legal protection).

Only one of the 32 SAF species was included within this category. This became the focus of new, targeted effort and resources over the five year project. It met the SAF criterion of being a ‘native species that is threatened and that is the focus of conflicts of interest with stakeholders with other objectives, and for which coexistence appears most insoluble.’ The species concerned was:

**Vertebrate**

- **Hen harrier**
Species management in Scotland 2007–2012

Hen Harrier

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Summary

• The hen harrier (Circus cyaneus) is one of Britain’s most alluring birds of prey, and one of the most threatened over parts of its breeding range.

• The SNH financial contribution to this SAF species covered its support of the Langholm Moor Demonstration Project (LMDP). The LMDP was devised to contribute to the resolution of a long-standing conservation conflict between raptors (including hen harriers) and grouse moor management. It consists of a partnership of Scottish Natural Heritage (SNH), Buccleuch Estates (land owner), Game and Wildlife Conservation Trust (GWCT), Royal Society for the Protection of Birds (RSPB), and Natural England.

• A seven year report gives preliminary results up to 2014. A full report will be published beyond the end of the project (September 2017) and scientific papers are being prepared for publication.

• The LMDP was launched in September 2007, and in 2008 the project employed five gamekeepers, a project manager and a project scientist. Prior to this, between 2003 and 2007, there were on average only 2.8 pairs of nesting hen harriers and exceptionally low numbers of grouse in the 12,000 ha study area. The work in the LMDP has since 2008 involved a combination of active moorland management (i.e. legal predator control and habitat management), diversionary feeding of hen harriers, and scientific monitoring of a wider range of bird and habitat features.

• Active management of the moor under the LMDP, other than ongoing heather habitat recovery following sheep reductions, ceased in spring 2016, with efforts currently being devoted to writing up the results of the work. The project is due to finish in October 2017.

Introduction

The conservation conflict

The conflict between raptor conservation and grouse moor management is long-running (e.g. Joint Raptor Study, JRS; Redpath and Thirgood, 1997; Ratcliffe, 2007; Park et al., 2008; Redpath et al., 2001, 2010; Fletcher et al., 2010, Baines and Richardson, 2013; Thompson et al., 2016; Young et al., 2016), and it currently receives considerable media attention. The conflict involving hen harriers has been especially acute, with fundamental differences of view over how the conflict should be managed (e.g. Ratcliffe, 2007; Thirgood and Redpath, 2008; Watson and Moss, 2008; Sotherton et al., 2009; Thompson et al., 2009, 2016; New et al., 2011; Elston et al., 2014; Avery, 2015; Uplands Stakeholder Forum, 2016).

Early ecological work on the hen harrier emphasised the constraining effects of persecution associated with grouse moor management on raptor conservation (e.g. Watson, 1977; Ratcliffe, 1990, 2007; Etheridge et al., 1997; Green and Etheridge, 1999; and see Watson and Moss, 2008 for other references). Recent work has shown a complex range of factors affecting hen harriers in different parts of their UK range, but with persecution still the most important constraint on their distribution (e.g. Anderson et al., 2009; Fielding et al., 2011).

Some people illegally kill hen harriers because of their potential impact on red grouse populations and shooting bags (e.g. Redpath and Thirgood, 2008; Sotherton et al., 2009; Thompson et al., 2009; Redpath et al., 2010; Hardey et al., 2013; Avery, 2015; Uplands Stakeholder Forum, 2016). There are two broad but non-exclusive approaches to reducing such persecution of harriers: those involving enforcement of existing laws, and those directed at achieving consensus and cooperation. Redpath et al. (2010) gave examples of measures actively considered since 2005: enforcement and support for a move to less intensive grouse moor management; intra-guild predation by golden eagles; diversionary feeding of harriers; and a scheme to manage harrier broods (see also Elston et al., 2014). They concluded that progress requires continued dialogue between the main stakeholders and a risk analysis based on improved understanding of the costs, acceptability, legality, feasibility and the environmental, economic and social consequences of following alternative approaches.
The development of a conservation framework for hen harriers (Fielding et al., 2011) and work to directly tackle illegal persecution of hen harriers (under the auspices of the Partnership for Action Against Wildlife Crime Scotland, PAWS) are ongoing. In particular, the Heads Up for Harriers project is successfully engaging members of the public and land managers in developing our awareness of harrier ecology. The RSPB Skydancer project has effectively raised awareness and promoted the conservation of harriers in the north of England, and has been extended cross-border by the RSPB Hen Harrier Life Project, including considerable use of satellite transmitters to track the birds throughout the year.

Diverting harriers from grouse through diversionary feeding, and putting in place habitat management and predator control measures to reduce other factors potentially suppressing grouse numbers, have been at the core of the Langholm Moor Demonstration Project (LMDP). For the rest of this chapter, we confine ourselves to the LMDP, developed as the sole work under the Species Action Framework (SAF) to address a conservation conflict (sensu Redpath et al., 2013) involving a conservation priority species – the hen harrier. It is noteworthy that human-wildlife conflicts are defined as: ‘… occurring when an action by either humans or wildlife has an adverse effect on the other. This term is problematic in part because it suggests that wildlife species are conscious human antagonists.’ (Redpath et al., 2013). However, conservation conflicts are defined as: ‘Situations that occur when two or more parties with strongly held opinions clash over conservation objectives and when one party is perceived to assert its interests at the expense of another. This definition recognises that conservation conflicts occur fundamentally between humans.’ (Redpath et al., 2013).

### Langholm Moor - a totemic area for grouse shooting

Langholm Moor has emblematic significance in grouse shooting circles. In Scotland, the record number of red grouse shot in a single day is 2,523 - killed by eight guns on 30 August 1911 on Roan Fell (part of Langholm Moor); another 1,266 grouse were shot there eight days later (Ratcliffe, 1990). In total, more than 20,500 grouse were shot on the Langholm Moor by the end of October that year (Ratcliffe, 2007). Since then, the number of grouse shot has declined, though large ‘bags’ continued to be shot until the early 1990s. The last time more than 3,000 brace (i.e. 6,000 individuals) of red grouse were shot was in 1934 and the last time 1,000 brace were shot was in 1992 (Fig. 1), the first year of the JRS and the last year of commercial shooting. Since 1996, no grouse shooting has taken place. One major habitat change across the moor has been the decline in moorland habitat dominated by heather (Calluna vulgaris). Between 1948 and 1988, approximately 48% of heather-dominated habitat at Langholm was lost, primarily through heavy grazing by sheep (Redpath and Thirgood, 1997). This is comparable with similar losses of heather cover across large tracts of the British uplands due to heavy grazing pressure and afforestation.

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**Fig 1.** Historic grouse bags at Langholm Moor 1933-1998. No grouse shooting took place after 1996.
(Thompson et al., 1995). Declines in heather cover at Langholm were probably ongoing until sheep grazing was reduced in 2010-11. From then, heather-dominated habitat has been recovering and extending (see Langholm Moor Demonstration Project, 2014).

From the perspective of a record shooting bag more than 100 years ago, Langholm Moor was viewed by some as the ideal and key moor on which to adopt and test management practices to resolve the conservation conflict between red grouse shooting interests and the conservation of raptors, especially the hen harrier (Redpath and Thirgood, 1997). In addition, the landowner, Buccleuch Estates, has had a long-standing desire to shoot driven red grouse again, and this has added impetus to finding ways of resolving this conflict.

Langholm Moor became the principal study moor in the Joint Raptor Study (JRS) from 1992 to 1997, which quantified the impact of hen harriers and, to a lesser extent, peregrine on red grouse numbers (Redpath and Thirgood, 1997). That work showed that predation by hen harriers and peregrines could reach levels sufficient to render red grouse shooting viable on Langholm Moor, but the evidence was less clear on the other five moors in the JRS.

In 1999, the gamekeepers were laid off at Langholm, and habitat and predator management virtually ceased. As a result, crow numbers and
fox population indices increased (the latter only recorded from 2003 onwards), breeding hen harrier numbers dropped to pre-JRS levels and grouse and breeding wader numbers declined to very low numbers (Baines et al., 2008). Only in spring 2008, when keepering resumed, did the management of the moor change significantly as part of the new LMDP.

A decade after the publication of Redpath and Thirgood’s 1997 report, the LMDP was developed by a partnership of SNH (chair), Buccleuch Estates (owner), GWCT, RSPB and Natural England. A Project Plan was devised, and the project was launched in Edinburgh in September 2007 by Michael Russell MSP, then Environment Minister. The LMDP was devised to deliver a ‘win-win’ situation of breeding raptors coexisting with commercial driven grouse shooting.

**Langholm Moor and hen harrier SPAs**

**Langholm Moor**

The 11,960 ha project area includes approximately 7,600 ha of upland moorland between the towns of Langholm and Newcastleton. The site falls into the Scottish Borders and Dumfries and Galloway Council areas (which together form the SNH Southern Scotland Area). Langholm Moor was notified as a Site of Special Scientific Interest (SSSI) in 1974 (and re-notified in 1985). The notified features of the SSSI include the assemblage of upland habitats (heather moorland, blanket bog, dwarf shrub heath, upland grassland, woodland and flushes), aggregations of breeding birds, and geology (Carboniferous-Permian igneous). The site was classified as a Special Protection Area (SPA) for breeding hen harriers under the EC Birds Directive in 2001. The boundaries of the SPA and SSSI are the same except for the exclusion from the SPA of a small area of woodland in the south and an area on the western edge of the site (Fig. 2). The vegetation is dominated by extensive blanket bog, dry heath and species-poor acidic grasslands, and there are frequent small areas of broad-leaved woodland associated with streams.

**SPAs for hen harriers**

Langholm Moor is one of 14 sites in the UK that qualify as SPAs for breeding hen harriers. Together these support, on average, 229 pairs, which amounts to about 47% of the British breeding population and about 3% of the European population (as in 1998, and quoted in the JNCC species account). The European population is estimated at 32,000-59,000 breeding pairs. Further details of the SPAs for hen harriers in the UK can be found in the JNCC species account (see Table 6.47a.1).

**Why was the hen harrier part of SAF**

The hen harrier met criterion 3a of the SAF as a threatened species that is the focus of conflicts between stakeholders with objectives for game management and raptor conservation. Given the detailed research carried out, as described above, it was timely in 2007 to initiate a key project to try and reconcile the stakeholders’ objectives.

**General ecology of hen harriers**

Detailed ecological accounts of hen harriers are given elsewhere (Watson, 1977; Hamerstrom, 1986; Hardey et al., 2013). Hen harriers are predominantly ground-nesting birds favouring areas of rank vegetation, such as heather, bracken, bog myrtle and rushes and the early stages of forestry plantations. The female typically lays four to six eggs between April and the end of May, and she incubates these for around 34 days. The chicks fledge at around 35 days after hatching. Occasionally a male mates with, and provides food for, two or more females. Hen harriers feed mostly on small birds and rodents, especially voles. Although rarely used for breeding, upland grasslands provide valuable foraging habitats. In winter, males and some juveniles move to lower reaches (farmland, marshland, fenland, heathland and river valleys), whilst many females and some males remain on the moor.

In Scotland breeding strongholds include Orkney, Arran, Islay, Mull, the Uists and parts of mainland Argyll and Perthshire (Hayhow et al., 2013). The Isle of Man (IoM) is also a stronghold, with smaller numbers in Wales, northern England, and Northern Ireland (Hayhow et al., 2013).

The most recent (2010) national (UK and the IoM) survey estimated the number of territorial pairs to be 662, of which 472 were confirmed as breeding pairs (Hayhow et al., 2013). This represented a significant 18% decline from the 806 territorial pairs estimated in 2004, but was not significantly different from the numbers recorded in 1998 (Hayhow et al., 2013). As in all of the previous surveys, Scotland held most (76%) of the UK and IoM population, estimated as 505 territorial pairs, which was 20% down on the 2004 estimate (633; Hayhow et al., 2013). A fourth national survey is being undertaken in 2016.
Aims

Aims and objectives for the LMDP 2008-2017

The LMDP was established as a ten-year project, much of which overlapped with the SAF which ran from 2007-12. The core objective was to establish Langholm Moor as a driven grouse moor and to meet the nature conservation objectives for the SPA and SSSI. Under this objective, the following elements were to be included as measurable ‘success criteria’:

- The project would be a demonstration of how to resolve conservation conflicts between moorland management for red grouse and raptor conservation.
- The hen harrier population would be maintained as a viable component of the SPA.
- The heather moorland habitat would be extended and improved beyond its state in 2002 (the date of the most recent survey of habitat condition).
- The number of red grouse shot would be sufficient to ensure the moor reaches a financially viable state.
- The wider upland bird community would increase in numbers.

These elements were reviewed every three years, guided by six evaluation criteria detailed in Section 5.5 of the Project Plan.

Management Action

The Project Plan - brief history

Following publication of the report of the JRS (Redpath and Thirgood, 1997) Langholm Moor ceased to function as a grouse moor. Wider relationships between game management and conservation groups were poor - arguably the worst they have ever been.

On the day the JRS report was published, the Chairman of SNH, the late Magnus Magnusson, announced the formation of a Moorland Working Group (MWG). Led by Colin Galbraith (then a senior staff member in SNH) the MWG was charged with building consensus between parties. Its members were drawn from the Game Conservancy Scottish Research Trust, the Game Conservancy Trust (now GWCT), RSPB, the Scottish Landowners’ Federation (now Scottish Land and Estates) and SNH. In July 1998, the MWG signed a Statement of Intent, Action for Scotland’s Moorland, calling for concerted action to support moorland management and conservation. It also bore the signatures of nine supporting organisations: British Association for Shooting and Conservation, the Heather Trust, National Farmers’ Union of Scotland, Royal Institution of Chartered Surveyors in Scotland, Scottish Association for Country Sports, the Scottish Gamekeepers Association, Scottish Raptor Study Groups, Scottish Wildlife Trust, and World Wide Fund for Nature (Scotland). The Statement made specific reference to Langholm Moor.

Further discussion led to the formation of the Moorland Forum in 2002. This developed into a unique partnership that engages with matters influencing the uplands of Scotland, and actively promotes improvements in policy, practice and management. The Forum now consists of 28 member organisations. It provides the prime opportunity for cross-cutting debate on the future of the Scottish uplands and its communities, and seeks consensus on key issues affecting the uplands, founded on a sound evidence base.

Importantly, that Forum (chaired first by Lady Isabel Glasgow, and now by the Earl of Lindsay) led discussions to develop a major demonstration project at Langholm which would address directly the conflicts between the conservation of birds of prey, other wildlife and habitat interests, and the objectives of driven grouse shooting. A small group was formed to take this work forward (SNH, Buccleuch Estates, GWCT and RSPB) under the chairmanship of Colin Galbraith.

On 23 September 2005 work began on the development of a project plan to guide this work, and two years later, on 22 March 2007, the Langholm Project Plan was concluded. Following detailed discussions and the development of legal documentation, a company governed by Project Directors was formed, with Natural England joining as the fifth partner. The Project was launched in September 2007 with a ten-year time frame set out in the Project Plan. This plan has proved critical in guiding the work of the Project, and has continually been the source of guidance for the wider governance and work of the Project.
Organisation of the work

Over the early years of the project, the following organisational structure and functions emerged:

- **Project Board** – This managed the work, and comprised funding partners (Buccleuch Estates, SNH, GWCT, RSPB and Natural England). Management of the Board rotated every three years between SNH and Buccleuch Estates, and was initially chaired by SNH. The Project Board met quarterly to consider reports from the Project Manager and annual reports from the Scientific and Technical Advisory Group (STAG). The Project Board reviewed progress, and in the third and seventh years reported on progress against the five success criteria.

- **STAG, the Science and Technical Advisory Group** – Drawing on scientific and land management experts, this group advised the Board on relevant matters of evidence, notably the results of the monitoring of the grouse moor, habitat and other management.

- **Science Contact Group** – Chaired by GWCT, this consisted of scientific staff working for the Project Board member organisations, and was actively involved in and advised on scientific and technical details of the work.

- **PR Group** – Chaired by GWCT, this attended to media issues and website content.

- **Staff** – A part-time Project Manager (Graeme Dalby) was appointed in 2008. He managed the Head Keeper (Simon Lester), responsible for a team of four under-keepers. The LMDP staff also included the Project’s Head Scientist (GWCT staff members seconded to the project: originally Damian Bubb, and from 2012 Sonja Ludwig) and 1-2 seasonal field assistants (RSPB employees seconded to the project) supported by several MSc and GWCT placement students, Raptor Study Group Members and volunteers. In 2012 a full-time PhD student (Richard Francksen), based at Newcastle University, joined the science team to study buzzards (he was awarded his PhD in 2016).

Project budget

Over the ten-year duration of the Project the annual budget was set as:

- **Moorland management** - £214,730 (the actual costs were considerably higher, estimated overall at approximately £450,000, with the extra cost incurred by Buccleuch Estates and SNH to cover e.g. heather regeneration and livestock removal).
- **Monitoring** - £75,150.
- **Project management and support costs** - £15,800.

The annual contributions were set as: £86,893 from each of SNH, Buccleuch Estates and GWCT; £30,000 from RSPB, and £15,500 from Natural England, but increased with the rate of inflation over the years. The Project aimed to receive income from driven grouse shooting (see figures in the Langholm Project Plan).

Management actions

Full details are given on the Project website and in specialist papers published or planned.

Most of the activities listed below were undertaken between 2008 and 2015, with the exception of livestock management (sheep numbers reduced from 2010 onwards) and strongyle worm control (which ceased in 2013-14).

Land and wildlife management

Four activities were undertaken.

- **Habitat management** - heather burning and cutting, bracken control, heather restoration, blanket bog management entailing treatment using glycophosphate on a 300 ha site to reduce purple moor-grass dominance, livestock management and goat control.

- **Legal predator control** – involving trapping and shooting to remove foxes, crows, stoats and weasels.

- **Application of medication for strongyle worm control** – to combat *Trichostrongylus tenuis*, an intestinal nematode parasite that can cause high mortality and reduced breeding success in red grouse and induce population crashes approximately every six years (Hudson, 1992; Newborn and Foster, 2002).

- **Diversionary feeding of hen harriers** – to divert harriers from red grouse, using techniques developed on Langholm Moor (e.g. Redpath et al., 2010).

- **A fifth technique, importation of grouse, was contemplated but not implemented given the steady increase in grouse numbers during the**
early phase of the project. Project partners also wished to demonstrate that a grouse moor could recover without such reinforcement using birds from other areas.

Monitoring
There were five components of monitoring:

- Red grouse numbers and productivity – assessments were made of abundance and breeding success, with counts in March/April and July.
- Red grouse mortality – using radio tags fitted to adult and juvenile grouse, the extent and possible causes of grouse mortality were estimated, in order to assess the impacts of predation, disease and other factors (see figure 5 in the Langholm Project Plan).
- Numbers and breeding success of hen harriers - numbers and breeding success of hen harriers were recorded. This work included nest watches, from hides and in later years nest cameras, to record prey brought back to chicks.
- Other birds and mammals – abundance of other raptors, ravens, waders, passerines and mammals was recorded annually, and in some cases more frequently. A PhD study undertaken by Richard Francksen based at Newcastle University focused on the diet and foraging behaviour of buzzards. A considerable amount of data were gathered on annual predator indices (fox scats, foxes killed by ‘lamping’, mustelid tunnels, sightings of corvids) and related to keepering intensity (traps set, hours lamped etc.) and its efficiency (numbers of predators killed).
- Habitat extent, composition and structure – this was determined through combinations of repeat aerial photographic surveys, with monitoring of vegetation within the grouse count areas and along permanent transects.

Results
As the project is ongoing, the data are currently being analysed and prepared for publication (e.g. Ludwig et al., in press). The reader is directed to detailed data and preliminary results in the seven year report and to the project website for updates on results and future publications.

Lessons Learnt, and Further Work
Given the nature of the Project, a lot of effort has been devoted to communicating the results of the work. Publicity has included:

- Six Government Ministers visiting the Project.
- More than 100 visiting groups of stakeholders visiting the Project to learn from project staff about heather restoration, diversionary feeding of hen harriers and many other aspects of the work in the LMDP.
- A Parliamentary Committee visiting the Project during careful consideration of the Wildlife and Natural Environment (WANE) Scotland Bill.
- Considerable media coverage (e.g. TV, radio, magazine articles and blogs).
- LMDP joining up with an educational awareness project, Making the Most of Moorland, focused on Langholm.

Over the duration of establishing and running this project much has been learnt about large project management, governance, and reporting. All of this will feature in the final report of the Project. Several key lessons include:

- The Project Plan was key to guiding the project. Often during the conduct of the work the original assumptions were questioned, and the Project Plan proved invaluable in setting out the rationale for these.
- One of the drawbacks of the Project Plan was that it sometimes proved inflexible. However, as Project partners took a long time to sign up to this, there was considerable reluctance to change any of the targets. This proved especially contentious in relation to the grouse targets, which some partners considered to be unrealistic as the Project developed.
- The impacts of sheep grazing, and importance of removing these for heather recovery, were not reflected in the Project Plan. Only after large numbers of sheep were removed from the moor (in 2010) was there a marked improvement in heather cover.
- The detailed scientific work, now being prepared for publication, will be crucial in revealing the relative importance of drivers of change in numbers and productivity of grouse, raptors and other wildlife.
• The challenges of adopting collaborative approaches to meeting sustainable moorland management objectives are considerable. What might be viewed as legitimate ‘good practice’ by one organisation may not have the support of others.

Further Information

http://www.langholmproject.com/ - Project website. In particular, the reader is directed to the seven year report, and Ludwig et al. (in press). The Executive Summary in the former (pages 6-7) gives a comprehensive overview of the findings, and presents the meeting of targets as red, amber or green.

References


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Acknowledgements

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Several individuals have provided invaluable scientific inputs over the years, and in addition to those named above we must thank: Mick Crawley, Peter Hudson, Ian Newton, Steve Redpath and the late Simon Thirgood. SNH Area and other staff have been ceaselessly helpful, and we thank Phil Boon, Roger Burton, Sarah Eno, Martin Gaywood, Chris Miles, Andrew Panter, Kay Prichard, Iain Rennick, Karen Rentoul and Ian Strachan. The Duke of Buccleuch, Mark Oddy and Simon Lester deserve special thanks for the remarkable industry and faith they have shown in the Project. We remember the late Gareth Lewis, Charles Connell, John Miles and Simon Thirgood who did so much to lay the early foundations for this work.

The SAF Partners

- Scottish Natural Heritage
- Buccleuch Estates
- Game & Wildlife Conservation Trust
- Royal Society for the Protection of Birds
- Natural England

The Species Action Framework Handbook

This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework.

The fourth situation identified under SAF where species management may be appropriate to achieve biodiversity aims is ‘sustainable use of species’. This occurs where a species in the wild is a resource of social or economic benefit (for example field sports, fisheries). Such use should be carefully managed, especially if it impacts upon biodiversity aims by threatening the target species’ population or by affecting the food webs and ecosystems in which the species plays a part.

Actions may include efforts to reduce the impacts of human activity on the species, for example through modifying harvesting methods or intensity. Alternatively, it may be necessary to increase management effort on the species if it is having negative effects on biodiversity aims.

Three out of the 32 SAF species were included in this category. These became the focus of new, targeted effort and resources over the five year project. They met the SAF criterion of being ‘Native species that provide important socio-economic benefits in the wild and whose use impacts upon biodiversity – this may include exploited species which are a conservation concern or exploited species which are not a conservation concern but may threaten wider biodiversity interests.’ The following species became the focus of new action under this heading:

**Vertebrates**
- Native deer – red and roe

**Invertebrate**
- Native oyster
Native Deer – Red and Roe

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Summary

- Scotland’s two native deer species, red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*), are widespread across Scotland. They contribute to Scotland’s biodiversity, tourism and economy, especially in rural areas. Deer can also have negative impacts on natural habitats, crops, forestry and public safety. With no natural predators, land managers play a vital role in managing these impacts.

- 2007 to 2012 was a period of significant change within deer management. In 2008, *Scotland’s Wild Deer: A National Approach* (WDNA) was developed by a broad range of organisations. This 20–year vision set the strategic approach for deer management during theSpecies Action Framework (SAF) period. In 2014 the first five-year Review of WDNA was completed and a new version published.

- A suite of 84 Wild Deer Best Practice Guides provided practical and technical guidance on deer management. Further guidance for deer managers was provided in the Code of Practice on Deer Management (Deer Code) which came into effect at the beginning of 2012.

- The challenges and opportunities associated with managing red and roe deer in the SAF period were set out in WDNA. The principal of these were to:
  1. Articulate the public interest associated with deer and their management and explain what sustainable deer management meant in practice.
  2. Encourage people, organisations and government to work together to deliver deer management.
  3. Encourage deer to be managed as part of an integrated approach to land management.
  4. Develop and deliver practical hands on training events to increase skills, knowledge and capacity within the deer sector e.g. Wild Deer Best Practice demonstration events and habitat impact assessment courses.

Introduction

Species background

There are two species of native wild deer in Scotland: red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*). The red deer is Britain’s largest native land animal and is an iconic species, often topping public opinion polls as the animal most associated with Scotland, and was one of Scotland’s Big Five animals. Woodland edge provides ideal habitat for red deer but they have adapted to the open hill and occur widely across upland regions. Roe deer is the most widely distributed deer species in Scotland and can be found across all habitat types. Roe are adept at expanding into new areas and are increasingly found in urban areas, including gardens, parks and community woodlands (Fig. 1).

![Fig 1. Roe deer in woodland.](image)

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Why were native deer on the Species Action Framework?

Red and roe deer satisfied the criteria for ‘sustainable use’ species (criterion 4 of the SAF; Scottish Natural Heritage (SNH), 2007). Deer are an important natural resource for Scotland. They contribute to Scotland’s biodiversity, tourism and economy and provide jobs, especially in rural areas. Wild deer management in Scotland was estimated in 2005 to be worth over £100 million annually to the economy, with more than 2,500 full-time equivalent jobs supported, many in remote and fragile communities (Public and Corporate Economic Consultants, 2006). However, deer can also have negative impacts on natural habitats, crops, forestry and on public safety. Costs can be significant, for instance road collisions with deer are estimated to cost £9.4 million a year (Putman, 2012). With no natural predators, man plays a vital role in managing these impacts.
Distribution and abundance of red and roe deer

The total population of wild deer in Scotland is not known. The most recent population counts give national estimates of 360,000–400,000 red deer and 200,000–350,000 roe deer (SNH, 2013a). Red deer numbers on the open hill have increased substantially (by about 75-80%) since the 1960s, although current count methodology may be more accurate than it was in the 1960s. More recently numbers have stabilised, and the most recent count data show a small decline of around 5% (Edwards and Kenyon, 2013).

Roe deer have been increasing since the 1700s, when they ‘disappeared in most regions of Scotland except for the northern Highlands’ (The Deer Initiative, undated). Roe are particularly difficult to count nationally and regionally, because so many are distributed across woodland, particularly around and within towns and cities.

At a local level it is important to focus on the impacts of deer (both red and roe) to achieve land management objectives. In recent discussions the Rural Affairs, Climate Change & Environment (RACCE) Committee concluded that ‘we need to continue to focus on the impacts of deer rather than their absolute numbers’ (Letter from Paul Wheelhouse, the Minister for Environment and Climate Change, to the RACCE Committee, 5 March 2014).

General ecology

Red deer have adapted to living on the open hill throughout much of Scotland. Groups of stags and hinds generally live separately, apart from during the rut. Hinds tend to be ‘hefted’ to a particular area and do not range far. More information on red deer ecology can be found on the Wild Deer Best Practice website.

Roe are generally seen in loose family groups or as individual animals. Does tend to be accompanied by their kids and bucks tend to be solitary, although they may form small groups in winter. More information on roe deer ecology can also be found on the Wild Deer Best Practice website.

History of managing wild deer

Nobody owns Scotland’s wild deer – they are res nullis. The right to shoot deer is inextricably linked to land ownership. Landowners have the right to shoot deer and they can pass on this right to employees and tenants. During the SAF period there was considerable thinking about what responsibility meant in the context of deer management. This resulted in the Deer Code. This explains: ‘…at the heart of the voluntary approach to deer management is that with this right to shoot or take deer on land goes a responsibility to safeguard their welfare and manage them sustainably’ (SNH, 2012). SNH is the government body tasked with promoting the conservation, control and sustainable management of deer in Scotland. However, these responsibilities are shared amongst all those who own or manage land where wild deer are found.

People are at the heart of wild deer management. Wild deer are not confined by human boundaries and as a result often need to be managed collaboratively. Deer Management Groups were established over 30 years ago to help manage deer, particularly in the uplands. Work to establish lowland deer groups has developed in recent years.

Aims

Aims for 2007-2012

The aim of the SAF implementation plan for native deer (SNH, 2007) was to:

- Promote the sustainable management of native deer populations to meet a range of private and public objectives relating to biodiversity interests.

The following types of actions were identified for the five-year period of the plan:

- Expand the programme of Joint Agency Working on designated sites with features identified as in ‘unfavourable condition’ in relation to deer impacts.

- Articulate the public and private benefit delivered through the sustainable use of native deer.

- Explore models for achieving sustainable deer management in a range of upland and lowland situations through the Sustainable Deer Management Project.

Work contributing to these actions was co-ordinated through WDNA.
Management Action

Overview

*Scotland’s Wild Deer: A National Approach* (Scottish Government, 2008) co-ordinated practical deer management actions and projects across a range of organisations during the SAF period. These actions responded to and were directed by legislative changes introduced through the Wildlife and Natural Environment (Scotland) Act 2011 (WANE Act). Discussions leading up to the WANE Act confirmed the Scottish Parliament’s desire to see wild deer management principally delivered on a non-statutory basis. This was underpinned by the Deer Code which sets out the public interests in deer management for the first time in a targeted way.

Another significant change during this period was the merger of the Deer Commission for Scotland with SNH in 2010 through the Public Services Reform (Scotland) Act 2010. This merger continued the trend of broadening the context within which approaches to deer management were being developed.

A number of major initiatives and projects have been co-ordinated through WDNA during the SAF period. Collaboration has been central to many of these.

Projects and initiatives delivered since 2007

2007 to 2012 saw the introduction of a number of significant policy, strategic and legislative changes affecting deer management. This period highlighted the important role that Scotland’s ecosystems play in delivering public benefits, including the health and wellbeing of the public and wider economic goals. This context is set out in the *Land Use Strategy* (Scottish Government, 2011a), the *Climate Change (Scotland) Act* 2009, the *2020 Challenge for Scotland’s Biodiversity* (Scottish Government, 2013) and the ensuing ‘route map’ (Scottish Government, 2015b). The Scottish Government’s *Economic Strategy* (2011b) also recognises that Scotland’s natural environment is a national asset. Its continuing health and improvement is vital to sustainable economic growth. Together these strategies recognised that healthy ecosystems, where deer and other herbivores are in balance with the environment, should deliver a range of public benefits including reduced carbon emissions, better water quality, increased productivity of woodlands, as well as improvements in deer welfare and performance.

Below is a summary of the main legislative, policy and strategic approaches developed during the lifetime of the SAF project.

*Scotland’s Wild Deer: A National Approach*

Up until 2008 deer management was guided by *Wild deer in Scotland: a long term vision* (Deer Commission for Scotland, 2000). In 2008 this was replaced by *Scotland’s Wild Deer: A National Approach* (WDNA) (Scottish Government, 2008). This set the strategic direction of deer management and the co-ordination of delivery on the ground for the majority of the duration of SAF.

WDNA includes guiding principles, a 20-year vision, objectives and key actions to direct deer management. It has recently undergone its first five-year review and a second version has been published (Scottish Government, 2015a). WDNA was developed, reviewed and is being delivered by a range of government and non-government organisations.

WDNA is being delivered through a series of rolling action plans, each covering a period of three years. The plans set out actions to be delivered across the deer sector. During the SAF project period the industry delivered four action plans and is now in the process of developing the sixth (2015–18). Each plan sets out actions for the coming year, gives a report on the previous year’s actions and sets priorities for the coming years. Since 2008 a range of organisations have delivered over 200 actions helping the economy, the environment and people and communities.

Fig. 2 shows the number of actions against each of the 2008 WDNA objectives and subsequent progress. This does not show the impacts of these actions but does give an insight into the number and breadth of actions achieved.

The Code of Practice on Deer Management

The Deer Code was introduced by Section 27 of the WANE Act and came into force on 1 January 2012 (SNH, 2012). It is a statutory code designed to support the voluntary approach to deer management. It sets out what land managers must, should and could do to deliver sustainable deer management. There is no statutory obligation to follow the Code (except for Public Bodies) but,
By 2030:

1. There will be widespread understanding and achievement of sustainable deer management so as to contribute to:
   - A high quality, robust and adaptable environment.
   - Sustainable economic development.
   - Social well-being.

2. Wild deer will be managed in an inclusive way with knowledge used to underpin all decisions.

Wild deer should be managed throughout their range in a way that:

1. Integrates deer management and other land-use objectives.
2. Uses collaboration to achieve the management objectives.
3. Uses a geographical scale and timescale best suited to achieving the management objectives.
4. Engages and communicates with all relevant interests.
5. Uses sound science and the best available evidence.
6. Promotes deer welfare.

Management of all species of wild deer will contribute to:

<table>
<thead>
<tr>
<th>A high quality, robust and adaptable environment</th>
<th>Sustainable economic development</th>
<th>Social well-being</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Contribute to healthy ecosystems and conserve and enhance biodiversity in the wider countryside.</td>
<td>a) Increase the economic opportunities associated with wild deer.</td>
<td>a) Contribute to a safe and healthy environment for people.</td>
</tr>
<tr>
<td>b) Secure the favourable condition status of Scotland’s sites designated for nature.</td>
<td>b) Minimise economic costs attributable to wild deer.</td>
<td>b) Increase participation in management and enjoyment of wild deer.</td>
</tr>
<tr>
<td>c) Help tackle and adapt to the effects of climate change.</td>
<td>c) Provide the skills and knowledge required to manage deer as an integral part of Scotland’s natural resources.</td>
<td>c) Manage the impacts of wild deer in and around communities.</td>
</tr>
<tr>
<td>d) Minimise further spread of non-native deer species in Scotland.</td>
<td>d) Contribute to the social and economic development of communities.</td>
<td>d) Promote venison as a healthy food.</td>
</tr>
<tr>
<td>e) Safeguard the welfare of all species of wild deer.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Conserve and enhance the cultural and historic environment and the distinct identity, diverse character and special qualities of Scotland’s landscapes.</td>
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</tbody>
</table>

Contributing to all objectives

a) Establish a shared, trusted and high quality knowledge base associated with wild deer to support local action.

b) Develop effective frameworks for sustainable deer management.

c) Raise awareness and understanding of wild deer and their management.
where there is damage by deer, whether or not the Deer Code has been followed would be taken into account.

The Deer Code is applicable to all wild deer in Scotland and it reinforces that deer management is required across all habitats and species. It highlights the need to manage roe in the lowlands and in urban areas as well as the more traditional forms of management of red deer in the uplands.

The Deer Code emphasises the need for collaboration and shows that we all have responsibilities to value deer and their habitats. It has been and will continue to be promoted throughout the deer sector.

Fig. 2 Chart showing progress on actions for each WDNA objective since 2008 (achieved, carried forward or superseded).
Wild Deer Best Practice Guides

A suite of 84 Wild Deer Best Practice Guides was published and launched in 2008. These guides were developed by a steering group of industry representatives and provide detailed, practical and technical guidance on a range of deer management skills, including butchering, habitat impact assessments and deer ecology. Revisions and additions to the guides are ongoing to ensure that they remain up-to-date and cover the key areas required by those involved in practical deer management.

There are approximately 2,500 WDBP subscribers, and demonstration events and workshops have been held around the country to explain some of the techniques and principles set out in the guides and to encourage wider awareness and uptake.

WDNA, the Deer Code and WDBP all work together. Fig. 3 shows the relationship between the three elements.

The Joint Working Process and Section 7 Control Agreements

The Joint Working Process was set up in 2004 to facilitate collaborative working amongst the agencies on deer management issues. The main purpose was to agree the most effective use of both incentive and regulatory tools and address those sites in most need of management action. A group formed of the then Deer Commission, Forestry Commission, SNH and Scottish Government agreed the strategic principles needed to work with land managers to deliver a co-ordinated approach to deer management. This Joint Working process has had a major influence on the delivery of deer management during the SAF period, particularly in relation to designated sites and achieving favourable condition.

Since 2007 there have been 12 Section 7 Agreements (SNH, 2013a). A Section 7 Voluntary Control Agreement, as per the Deer (Scotland) Act (as amended), is a voluntary, formal agreement which sets out specific deer management measures to be carried out to prevent damage to an identified public interest.

Since 2007 the focus has been on achieving favourable condition of designated features i.e. those habitats or species recognised to be important on specific protected sites. A recent assessment concluded that, of the 942 features in the red deer range, 23% are in unfavourable condition (SNH, 2013a). However it has been and continues to be difficult to differentiate data on deer impacts from those of other herbivores. SNH is currently carrying out more work to distinguish between these different herbivore impacts.

Deer vehicle collisions (DVCs)

A project was set up to assess the scale and distribution of DVCs, to develop a database of DVCs in Scotland and to try and identify potential black spots. The research estimates that there are likely to be in the region of 7,000 to 10,000 DVCs in Scotland each year. A report was published in 2011 covering research and data collated from 2008 to 2010 (Langbein, 2011). During this time actions such as deer fencing, vegetation management, focused deer control and different types of signage to improve driver awareness have been carried out in priority areas to try and reduce the risks of DVCs. While much progress has been made with this project, this area of work will continue to be a priority.

Urban deer

During this period there has been a growing interest in deer in and around urban areas. This has been a challenging area of work because of the fragmented land ownership in urban areas and because of the dense human populations. A report on The Management of Deer in Peri-urban Scotland (Dandy et al., 2009) concluded that managing interactions between deer and people
was critical to the successful management of deer in urban areas. Guidance on how to achieve this was trialled at three sites: Mugdock Country Park, Loch Ardinning Scottish Wildlife Trust Reserve, and Beecraigs Country Park.

During 2010/11 the first full year of thermal imagery census, which involved four local authorities, was carried out. This helped to develop a better understanding of the distribution and number of roe deer in specific urban areas. Thermal imagery census will continue to be used as a tool to inform local deer management and help involve and inform stakeholders.

**Deer management and Scotland’s woodland expansion target**

In 2006 the revised *Scottish Forestry Strategy* was published (Forestry Commission Scotland, 2006). This included an aim to increase Scotland’s woodlands to about 25% of our land area. The Woodland Expansion Advisory Group (2012) represented this as 100,000 hectares of woodland over the period 2012-22. This is part of Scotland’s efforts to adapt to and mitigate against climate change.

This woodland expansion target has had a significant impact on approaches to deer management during the SAF period, including the provision of grants. Planting trees in the presence of deer can be challenging. The use of fences has been guided by the *Joint Agency Fencing Guidelines*, published in 2004. These guidelines set out what needs to be considered, including deer welfare and public safety, and have to be followed where public money is being used to erect the fence/s.

One of the recommendations from the Woodland Expansion Advisory Group was that ‘Upland red deer range has the potential for the creation of significant areas of woodland, especially where it can provide shelter to improve deer welfare and make a positive contribution to the environmental value of the land’. In the longer term areas of woodlands in the uplands will provide forage and shelter. Having areas of woodland can also reduce the impacts on nearby fragile habitats. Planting in the lowlands has also brought challenges and opportunities. New woodlands have and will increase the habitats for roe deer. In urban settings this means taking into account the impacts on road safety in particular.

One of the remaining challenges is for deer/land managers to understand how much woodland their land can accommodate. Mindsets are changing and this period has seen a gradual shift away from the dualistic view of deer versus woodlands to recognition that woodlands planted in appropriate places can benefit deer, land managers and the surrounding environment.

**Case studies on sustainable deer management**

From 2008 to 2010 the Sustainable Deer Management Project sought to develop a better understanding of the key components and processes behind sustainable deer management. It drew on the findings from over 90 individual meetings with landowners, factors, stalkers, non-government organisations (NGOs) and community councillors. A report on *Sustainable Deer Management: A Case Study* (Rose, 2010), collated this range of views. It concluded that the main elements of sustainable deer management were to: safeguard deer welfare, conserve/ enhance biodiversity, maintain balanced integration between forestry, agriculture and the natural heritage, minimise costs associated with deer management, and ensure that deer management is proactive. This report paved the way for and has been drawn on and referenced in the development of the Deer Code.

**Deer research**

A broad range of research areas were explored during 2007–2012. Subjects of reports produced included: deer impacts on blanket bogs in the Monadliaths (Campbell and Marchbank, 2013), the management of roe deer in peri-urban Scotland (Dandy et al., 2009), understanding perceptions of deer and their management (Green et al., 2013), and understanding the costs and benefits of deer management (Putman, 2012). Together these helped to develop our understanding of and approaches to deer and their management.

**Deer Management Groups and Lowland Deer Network Scotland**

Deer Management Groups have been established over the last 30 years, with some dating back almost 50 years. The Groups cover much of the uplands of Scotland, are voluntary and
are predominantly in the uplands. They play important roles in the collaborative management of a common resource and helping to reconcile potentially conflicting land uses. There are currently about 45 functioning upland DMGs of which 41 are now in the process of developing ‘effective’ Plans (ADMG response to Convenor of RACCE Committee, 15 June 2015). During the SAF period expectations of DMGs changed and increasingly their role in contributing to delivery of the public interest came to the fore. This has resulted in a specific focus on the deer management planning process, building the capacity of deer management groups and developing ways of dealing with conflict. The DMG benchmark, published in 2014, which sets out criteria whereby a DMG can assess its effectiveness against the Deer Code, is an example of work helping to take this forward. The reviewed WDNA includes priority actions for 2015-2020 to contribute to and help deliver collaboration and effective deer management planning and implementation. This will continue to be a key focus over the next few years.

Whilst there are well established Deer Management Groups in the uplands, this arrangement has been lacking in the lowlands. The Lowland Deer Network Scotland (LDNS) was launched in November 2012 to address this, at a conference on deer in the lowlands held in Peebles. LDNS is a network taken forward by organisations with an interest in deer management and deer welfare. It aims to address the growing need for deer management in lowland and urban areas.

Since its launch LDNS has established good connections with local authorities. This remains a challenge in active planning but will continue to help consolidate and build on the collaborative networks and partnerships to manage deer in the lowlands.

**Other key achievements since 2007**

**Promotion of wild venison as a healthy meat**

The first ‘Eat Scottish Venison Day’ was launched in September 2009 by the Scottish Venison Working Group (now Scottish Venison Partnership), which includes producers, processors, assurance scheme representatives and agencies. This was a flagship event seeking to promote Scottish venison.

The Deer in Scotland Education Zone, a website resource providing information and materials, including activities, facts and worksheets on venison and deer management was launched at Scone Game Fair 2012 by the Minister for the Environment. It is aimed at primary and secondary schoolchildren and is based on the Curriculum for Excellence.

**Deer Competence Working Group**

Another significant change introduced by the WANE Act was the requirement for SNH to monitor the effects on deer welfare of the current levels of competence among those who shoot deer. A Deer Competence Working Group was formed of representatives from across the deer sector in 2012. The group agreed the standard needed for deer competence as being Deer Stalking Certificate Level 1 or equivalent.

**What have been the principal issues facing deer managers since 2007?**

A number of key issues have emerged and or developed during the period of SAF. Some of these are outlined below:

**Protecting designated sites vulnerable to deer impacts**

A major part of the effort in deer management from 2007 to the present has been trying to get designated sites at risk of damage by deer into favourable or recovering condition. All work to date has been achieved through a partnership of public agencies and land managers and will be continued in 2015 and beyond.

**Conflict resolution and balancing objectives**

Balancing opposed objectives within deer management continues to be a challenge. If for example one estate wishes to manage its deer as a sporting resource and its neighbour wishes to manage its area to establish new woodland, this can lead to tension. Nature conservation objectives are seen, in some circumstances, as an unwelcome imposition on those that manage deer. This can act as a barrier and make it difficult to reconcile different management objectives. Resolving this
relies on effective conflict management - the tools, skills and motivations for this need to be further developed and promoted. Much work has been done and is being done to identify and develop tools to help resolve conflict. As the pressures on land increase so will the need for effective conflict resolution.

Road Safety

Reports suggest there has been an increase in deer vehicle collisions since 2007. One of the reasons for this may be an increase in roe populations in urban areas. Awareness campaigns have been run, with press articles alerting drivers to the possibility of deer on the roads and the use of Variable Message Signs. These campaigns are particularly focused on the spring and autumn clock-changes. This area of work remains a priority.

Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

The principal lessons learnt during this period are the need to:

- Understand better how to support the voluntary approach to deer management.
- Build on work to develop conflict management tools.
- Be clearer on the priorities within deer management and express them in a way that practitioners can understand.
- Promote the contributions made by the deer sector to deer management (for example better promotion of the WDNA Action Plan).
- Encourage more action to protect ecosystem health, both within and outwith designated sites.

Future recommendations

Areas for future work include:

- **Supporting the non-statutory approach to deer management.** The WANE Act discussions through parliament concluded that the voluntary approach to deer management should continue to be supported. However this is still coming under scrutiny, with evidence having been submitted to the RACCE Committee in 2013/14. In particular we need to continue to support and build capacity for Deer Management Groups and the deer management planning process in both rural and urban environments.

- **Helping private/public working together.** At the heart of WDNA is the recognition that deer are managed by people working together. WDNA has been delivered by a blend of private and public but the majority of the actions (approximately 70%) have been delivered by public bodies. This is perhaps reasonable and inevitable. However to continue to deliver sustainable deer management we need to forge better working relations between public and private interests and ensure that we are recognising all the efforts of private interests in delivering public benefit.

- **Developing and supporting conflict resolution tools.** As mentioned above there continues to be a need to develop and use conflict resolution tools. Work continues to identify new tools. We need to trial these and also enable groups and individuals to recognise situations where they could/should be used. These tools will focus on facilitating negotiation to achieve compromise between land management objectives.

- **Taking more action to address ecosystem health.** Since 2008 there has been an increased focus on ‘ecosystem health’ and an understanding of the importance of healthy ecosystems underpins the 2014 reviewed WDNA. We need to support and encourage actions which contribute to the 2020 Biodiversity Challenge. We need to recognise the pivotal role of ecosystem health in delivering social and economic benefits from deer management.

- **Developing a better understanding of deer in the low ground.** Deer are increasingly found in urban and other lowland areas. We need to understand the implications of this to address any issues and capitalise on any opportunities.
Key Management Messages

- Deer contribute to and impact on a range of public interests.
- Deer should be managed collaboratively in most circumstances.
- A 20-year vision, challenges and priorities for deer management are set out in Scotland’s Wild Deer: A National Approach.
- Responsibilities for deer management are set out in the Code of Practice on Deer Management – this applies to anyone who owns or manages land on which deer occur.

New and ongoing work since SAF ended

- The first five-year review of WDNA has been carried out and published (Scottish Government, 2015a). This includes a set of priorities for 2015-2020.
- The 2015-2018 WDNA Action Plan is currently under development. This is part of a series of rolling Action Plans which will be refreshed on an annual basis.
- Further WDBP Guides have been developed e.g. on Muntjac. Revisions to existing guides and new guides will continue to be developed.
- A self-assessment process for DMGs has been developed and baseline information established.
- A number of Lowland Deer Groups have been established, further Groups will be established in the future.

Further Information

http://www.snh.gov.uk/land-and-sea/managing-wildlife/managing-deer/ – further information on deer can be accessed through the SNH website
http://www.deer-management.co.uk/dmgs/deer-management-groups – further information on Deer Management Groups can be accessed through the ADMG website
http://www.bestpracticeguides.org.uk – further information on Wild Deer Best Practice Guides can be accessed through the WDBP website

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The SAF Partners

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- British Association of Shooting and Conservation (BASC)
- British Deer Society (BDS)
- Cairngorms Deer Advisory Group (CDAG)
- Cairngorms National Park Authority (CNPA)
- Forest Enterprise Scotland (FES)
- Forest Research (FR)
- Forestry Commission Scotland (FCS)
- John Muir Trust (JMT)
- Lantra
- Loch Lomond and The Trossachs National Park Authority (LL&TNP)
- Scottish Environment LINK (LINK)
- Scottish Land and Estates (SLE)
- Scottish Gamekeepers Association (SGA)
- Scottish Government (SG)
- Scottish Natural Heritage (SNH)
- Transport Scotland
- Scottish Venison Partnership (SVP)
- University of the Highlands & Islands (UHI)
- Wild Scotland

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Native Oyster

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Summary

- The native oyster (Ostrea edulis) was formerly widespread around the coast, forming extensive beds of economic significance until the late 19th century. Its distribution in the wild in Scotland is now relatively restricted with a stronghold on the west coast. It remains under threat locally from illegal fishing and is potentially vulnerable to disease.

- Awareness-raising about the plight of native oyster has coincided with a marked reduction in illegal oyster harvesting.

- Restoration of oyster populations could be undertaken at regional or local scales.

- Regional, large-scale restoration projects face significant challenges, including the availability of an appropriate source of spat oysters, and are unlikely to be developed in the near future.

- Smaller-scale, local restoration projects could provide the most feasible way forward in Scotland, particularly where existing management measures could offer protection from potentially damaging activities. However, the availability of spat remains a significant constraint.

- Surveys were carried out around Shetland, at locations based mainly on previous records. Historically, native oysters were reported from 29 locations off Shetland. The use of historic sites did not prove to be a reliable means of identifying sites for relocating oyster beds as, in most cases, the underlying habitat is no longer suitable. During the survey no native oysters were located.

- The conservation status of the native oyster in Scotland is likely to be improved through the designation of a Nature Conservation Marine Protected Area at Loch Sween in 2014, and its listing as a Priority Marine Feature.

Why was this species on the SAF list?

Native oyster met criterion 4 of the Species Action Framework (SAF) (Scottish Natural Heritage, 2007) as a threatened species of socio-economic value requiring action to ensure sustainable use. The population has declined, having been lost from many sites and significantly depleted at others, largely through historic overharvesting in the 19th and 20th centuries (University Marine Biological Station Millport (UMBSM), 2007).

The distribution of native oyster in the wild is now relatively restricted with a stronghold on the Scottish west coast. It remains under threat locally from illegal fishing and may be vulnerable to pathogens and disease. Native oyster could potentially therefore have also met criterion 1a as a native species which has undergone a significant decline and which is endangered.

There was sufficient knowledge of the species to apply effective targeted action. Native oyster is a potentially valuable resource that could be sustainably harvested if its population status is improved, unlawful fishing is ended and there is a robust management framework. Furthermore, both been harvested for food around the British Isles, largely from free-living populations under both public and private management. The oyster was highly regarded as a food source, but a century and a half after a substantial population decline its cultural significance has largely been lost (zu Ermgassen et al., 2013). Once part of the diet of people on a modest income, the oyster is now better known as a luxury food item.

Introduction

Species background

Native oyster (Ostrea edulis), also known as European flat oyster, is a marine bivalve mollusc native to the east Atlantic, from Morocco to Norway (Fig. 1). For centuries, native oysters have been harvested for food around the British Isles, largely from free-living populations under both public and private management. The oyster was highly regarded as a food source, but a century and a half after a substantial population decline its cultural significance has largely been lost (zu Ermgassen et al., 2013). Once part of the diet of people on a modest income, the oyster is now better known as a luxury food item.
management of ‘wild’ stock/habitat and cultivation have the potential to contribute positively to the recovery of the species.

In addition to having an historic cultural importance, the conservation importance of native oyster has been widely recognised through a number of mechanisms. It was identified as a UK Biodiversity Action Plan (UKBAP) Priority Species and is included on the Scottish Biodiversity List (SBL) and the list of Priority Marine Features (PMFs) in Scotland. The international context for conservation importance is reflected in the inclusion of native oyster and native oyster beds on the OSPAR List of Threatened and/or Declining Species and Habitats (OSPAR Commission, 2009, 2013) under the Convention for the Protection of the Marine Environment of the North East Atlantic.

Habitat, distribution and abundance

Native oysters live on the seabed in relatively shallow coastal waters and estuaries, typically from the lower shore to about 10 m depth, but may extend down to 80 m (Gercken and Schmidt, 2014). They prefer habitats sheltered from strong wave action, which tend to be muddy, but require something hard for larval settlement – usually shells or stones (Fig. 2).

The oyster fishery was extremely valuable and the distribution was mapped as early as 1883 (Olsen, 1883). At that time it was reported to occur in the southern Moray Firth, along much of the south-east coast of Scotland, and in the south-west of Scotland, including the Solway Firth and the east coast of Kintyre. The current distribution has declined, but is poorly mapped. Native oysters are found (or have been known to occur) at locations around the whole of the UK from the Thames estuary to the Northern Isles. In Scotland, they now mainly occur in scattered populations fringing sea lochs on the west and north coasts.

General ecology

The native oyster may live up to 15 years, but about six years is more usual. It is an active filter-feeder, taking plankton and particulate matter from the water column. This species has an unusual life history as an alternating hermaphrodite that may change sex successively throughout its life.

Where oysters occur in sufficient density they may form oyster beds, a habitat of considerable ecological value. Oysters enhance biodiversity through the stabilisation of sediments and increasing the complexity of the seabed, thus increasing space for the settlement of other species (Barnes and Coughlan, 1971; Barnes, 1973; Gercken and Schmidt, 2014). In addition, through the action of filter feeding, oysters can process significant quantities of water. This can be locally important in energy and nutrient cycling by removing organic matter from the water column (Dame et al., 1984; Coen et al., 2007).

History of fishery and current threats

The native oyster has been harvested or cultivated for centuries and once supported a prolific fishery in several parts of Scotland, perhaps the best known example being in the Firth of Forth. The native oyster fishery of the Forth once covered over 166 km² of seabed and, from the 13th century, was the most commercially important in Scotland (UMBSM, 2007). At its peak, landings from the Newhaven fishery alone totalled 59.8 m oysters between 1834 and 1836. The superior reputation of the Forth oysters was so widespread that they were transported to Glasgow, western Scotland, England and the Continent for consumption and on-growing. Various attempts at managing the fishery (establishing close seasons, minimum sizes
for market, bans on exportation for on-growing) failed and by the 1870s, under extreme pressure from harvesting and illegal poaching, the fishery began to collapse, eventually ceasing entirely in 1920 (UMBSM, 2007). Surveys of the Firth of Forth carried out in 1957 reported that native oysters were not only commercially extinct but were biologically extinct since no living oysters were found (Harding, 1996). Periods of stock decline in the Forth and elsewhere have resulted in the importation of oyster stocks into a variety of locations in Scotland from overseas in efforts to establish or replenish fisheries (UMBSM, 2007). There remains only one active oyster fishery in Scotland (in Loch Ryan) and a number of sites where they are cultivated on a relatively small scale. Only 19 t of native oyster were produced in Scotland in 2013, compared to 297 t of Pacific oyster (*Crassostrea gigas*) (Marine Scotland, 2015).

A similar pattern of decline was recorded in oyster fisheries elsewhere in the UK and in continental Europe, including along the North Sea coast of the Netherlands, Belgium and Germany (OSPAR Commission, 2009; Gercken and Schmidt, 2014). Current issues and threats to the native oyster include illegal harvesting and the potential impacts of pathogens and disease. The parasitic protist *Bonamia ostreae*, introduced to Europe in the 1980s, is spreading along European coasts. *B. ostreae* is thought to have been introduced accidentally from California with the Pacific oyster, which itself was imported to create a new oyster fishery. The resulting disease, bonamiasis, can result in up to 80% mortality amongst native oysters (Laing et al., 2005). The first Scottish case of *B. ostreae* was recorded in Loch Sunart in July 2006, and in 2014 movement restrictions remained in force in both Loch Sunart and West Loch Tarbert (Marine Scotland, 2015).

**Aims**

**Aims and objectives for 2007-2012**

Two objectives were proposed for the SAF project 2007–12, which in turn were based on wider UKBAP objectives:

- Maintain and, where appropriate, expand the existing geographical distribution and abundance of the native oyster within Scottish inshore waters.
- Secure effective management mechanisms for exploitation and cultivation, and end illegal fishing.

The types of actions identified to achieve these objectives were:

- Conduct further research to support development of policy and management actions, including:
  - Investigation of methods for habitat enhancement/recovery (to promote recruitment).
  - Consideration of reintroduction to sites where oyster is now absent.
- Implement findings of above research to expand abundance and distribution of native oysters.
- Continue the campaign to end unlawful harvesting.
- Develop good practice guidelines to prevent the translocation/introduction of non-native species which would pose a threat to the native oyster.

**Management Action**

**Summary of the main actions carried out**

A steering group involving the partners (listed at the end of this chapter) was established that provided for liaison between members and oversight of the work that was undertaken on the native oyster. This included:

- A survey of previously known oyster beds in Shetland.
- A Scottish Aquaculture Research Forum (SARF) project titled ‘Development and delivery of a proposal for re-establishment, on a pilot scale, of a native oyster population in Scotland’, undertaken by the University of Stirling with partner funding from Scottish Natural Heritage (SNH) and the Crown Estate.
- Development of an advice package for small-scale oyster restoration projects.
- Ongoing liaison to maintain awareness about illegal harvesting (e.g. through the distribution of the SNH [native oyster information leaflet]).
Survey of previously known oyster beds off Shetland

A study was commissioned (Shelmerdine and Leslie, 2010) to identify suitable areas around Shetland for restocking native oyster in the hope that, in the long term, native oyster beds will become self-seeding. Potential areas were identified from historical accounts, current records and cartographic tools.

The main findings of the Shetland survey were as follows:

• A total of 29 areas around Shetland were identified as historical locations for native oyster. The majority of these were located on the west coast.
• Of these areas, Lang Sound and South Voe, between East and West Burra, were regarded as the most important oyster fishery in Shetland.
• The decline of the Shetland oyster fishery was probably due to a combination of overfishing during the 1890s and severe winter weather conditions during 1914.
• No native oyster specimens were found during the new survey; however, Roe Sound and Tresta Voe were the most suitable surveyed areas for potential restocking (i.e. reintroduction). Weisdale Voe and Stromness Voe were identified as potential sites for future investigations.
• Historical information on previous fishing grounds was not found to be a suitable methodology for locating present-day native oyster stocks. A combination of habitat maps and recent live sightings is thought to be of more benefit.

Lessons Learnt, Further Work and Future Recommendations

Lessons learnt

The ongoing liaison and awareness-raising about the damage caused by illegal oyster harvesting has been largely successful, with a marked reduction in activity at key locations. Progress on restoration projects was not so successful. It was concluded that moving forward with a large-scale restoration project (i.e. multiple sites on a regional level) is not currently feasible. A number of factors contributed to this conclusion, including the lack of an appropriate source of spat oysters within Scotland. If a suitable hatchery source were to be developed in the future it would be worth revisiting the concept of a large-scale reintroduction. Any such project would need to apply the Scottish Code for Conservation Translocations (National Species Reintroduction Forum, 2014) that has been produced since the SAF work finished, and may need to be licensed by SNH.

In the meantime, small-scale projects to reintroduce or reinforce populations of oysters in individual locations where they were formerly abundant may be appropriate. A web-based guidance package (based on the SARF project outputs) is being developed to support and facilitate such projects.

New and ongoing work since SAF ended

The objectives identified above remain valid and a number of actions have built upon the work of the native oyster SAF project.

Subsequent to the inclusion (in 2008) of native oyster and native oyster beds within their List of Threatened and/or Declining Species and Habitats, the OSPAR Commission has made recommendations for furthering the protection and conservation of native oyster within the OSPAR maritime area (OSPAR Commission, 2013). Amongst other matters, these recommendations require contracting nations to consider whether any locations justify selection as Marine Protected Areas for the conservation and recovery of native oyster or native oyster beds; to further improve knowledge of species; and to improve management of activities that could adversely affect oysters.
In Scotland, these recommendations are being met in a number of ways. As part of the process for establishing a network of Nature Conservation Marine Protected Areas (NCMPA), native oyster was included as a search feature to help identify sites. The first NCMPA with native oyster as a protected feature, Loch Sween in Argyll, was designated in 2014. Management measures have since been implemented by Marine Scotland prohibiting any form of fishing for native oysters there. Work is continuing to identify further sites for native oyster within the network. In addition, the ongoing survey and monitoring programme for the MPA process continues to add to our understanding of native oyster abundance and distribution.

As a further measure, the native oyster has been listed as a Scottish Priority Marine Feature (PMF). The intention of the PMF list is to help focus future conservation action especially in the context of the new marine planning process, but also to direct research and education and promote a consistent approach to marine nature conservation advice.

To further support the development of oyster restoration projects, SNH is currently funding a Marine Alliance for Science and Technology for Scotland (MASTS) PhD studentship at St Andrews and Heriot Watt Universities. This project is investigating aspects of larval oyster behaviour, assessing the characteristics of settlement substrates and modelling habitat suitability, to inform the identification of sites for oyster restocking.

Key Management Messages

- Illegal harvesting of native oyster remains a significant threat but appears to have reduced following liaison and awareness-raising.
- Large-scale restoration at a regional scale is not currently possible due to constraints, predominantly the lack of available oyster stock.
- Restoration at a local scale, primarily for biodiversity purposes, is feasible.
- We need to improve our knowledge of the status of native oyster populations around Scotland.

Further Information

http://www.scotland.gov.uk/Topics/marine/Fish-Shellfish/aquaculture/diseases/notifiableDisease/Bonamiaostreae – Scottish Government advice on Bonamia infection.
References


OSPAR Commission. 2013. Recommendation 2013/4 on furthering the protection and conservation of Ostrea edulis in Region II of the OSPAR maritime area and Ostrea edulis beds in Regions II, III and IV of the OSPAR maritime area. OSPAR(2) 13/4/1, Annex 7.


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The SAF Partners

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- SAMS
- Scottish Aquaculture Research Forum
- Scottish Natural Heritage
- SEPA
- Shellfish Association of Great Britain
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