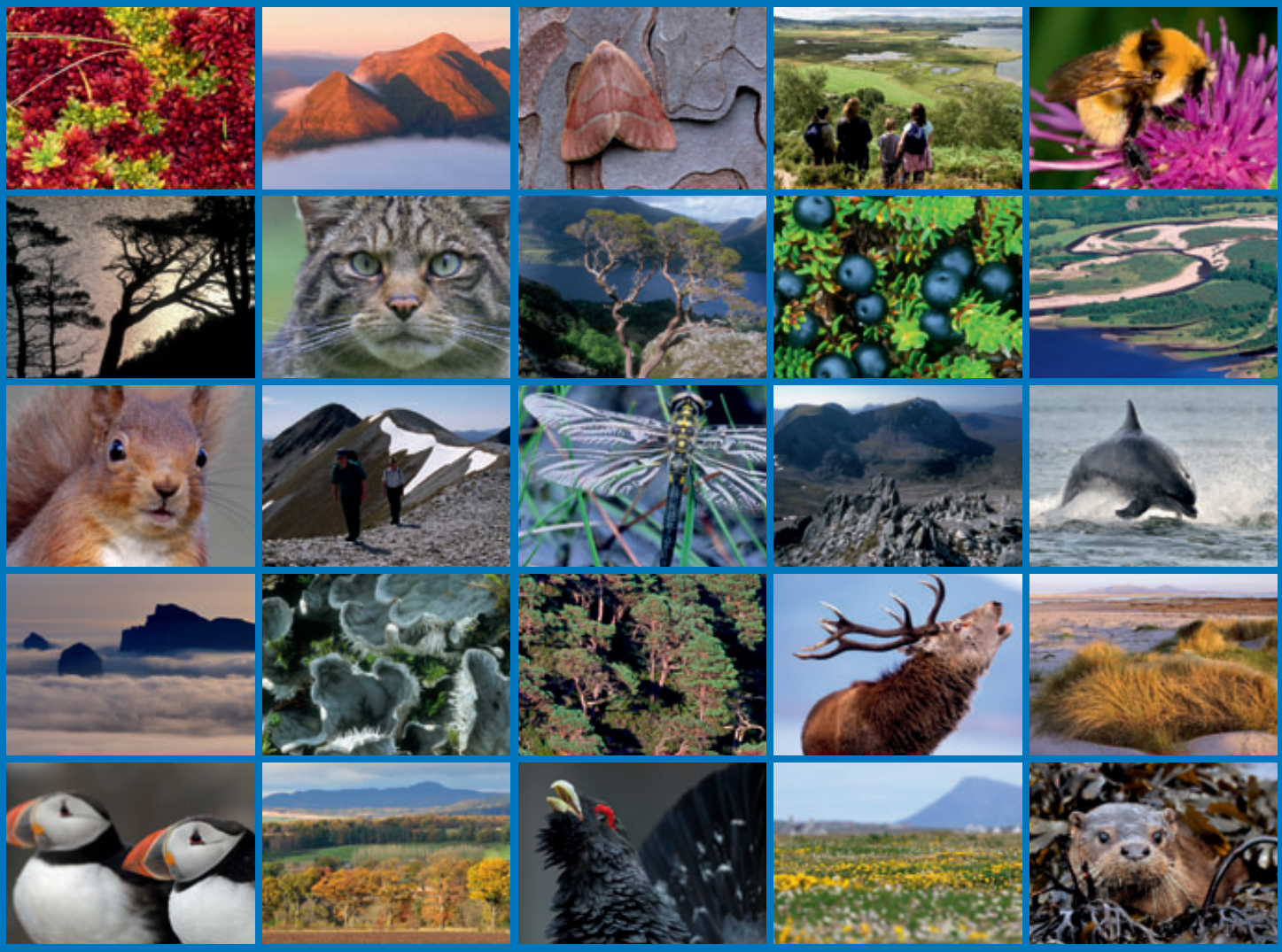
Scottish Natural Heritage
Commissioned Report No. 510

The Scottish Beaver Trial: Ecological monitoring of the European beaver *Castor fibre* and other riparian mammals – Second Annual Report 2011



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COMMISSIONED REPORT

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The Scottish Beaver Trial: Ecological monitoring of the European beaver *Castor fiber* and other riparian mammals – Second Annual Report 2011

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COMMISSIONED REPORT

Summary

The Scottish Beaver Trial: Ecological monitoring of the European beaver *Castor fiber* and other riparian mammals – Second Annual Report 2011

Commissioned Report No. 510, (iBids Project No. 7062)
Contractor and Partner: The Wildlife Conservation Research Unit, University of Oxford.
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Background

In 2008, the Scottish Government approved a licence for the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS), to undertake a five-year trial reintroduction of the European beaver *Castor fiber* after an absence of over 400 years. The aims of the trial include an assessment of the ecology of the beavers, and their impacts on the Scottish environment. The success or failure of the trial will be based on a number of specific criteria, which relate to the ability of the reintroduced population to sustain itself, the effects of the beavers on biodiversity, the economic effects of the beavers, and the cost of their reintroduction and ongoing management.

In order to effectively assess the Scottish Beaver Trial (SBT), Scottish Natural Heritage (SNH) is coordinating a monitoring programme, in collaboration with a number of independent organisations. A core element of this is the monitoring of the beaver population itself. SNH is, therefore, working in partnership with the Wildlife Conservation Research Unit at the University of Oxford (WildCRU) in order to ensure the monitoring of the beavers, and other riparian mammals present at Knapdale, is suitable and appropriate. WildCRU are responsible for independent analysis of data received on the ecology of the released beavers; this is the second of five annual reports planned over the duration of the Scottish Beaver Trial. The aim of this report is to report on the monitoring methods that are being carried out (including continual appraisal of, and amendments to, those methods), to summarise the data gathered on the ecology of the beaver population and other riparian mammals, and to present relevant analyses that address key ecological questions. The first report covered the period 30th May 2009 (when the first beavers were released) to 7th July 2010. The current report collates data from the first and second year of the trial, to June 2011.

Main Findings

A total of fifteen beavers in five families or pairs were released during the first year of the trial, and one further animal during the second year of the trial. Three deaths, all males, were recorded during the first year. A further three animals were also classified as 'missing' (fate unknown) by the end of the first year. No further deaths were recorded during the second year of the trial but one further animal was recorded as missing. Two of the missing animals were sub-adults. As of June 2011, of the 16 animals released over 2009 and 2010, nine were believed to be alive and

present in the release area. Two wild-born yearling animals, born in 2010, were also present. During the second year of the project, preliminary trials investigating the potential use of inexpensive GPS transmitters indicated that GPS tracking would be a useful monitoring tool. Therefore, further amendments have been made to the ecological monitoring methods, including a renewed emphasis on radio-telemetry (GPS) and, accordingly, decreased emphasis on observational methods (put in place in 2010 as a replacement for VHF telemetry). Field sign surveys continue to provide essential ecological information and provide continuity for the data collected thus far. At the end of the second year of the trial there were sufficient data to show that four beaver families or pairs had successfully established territories (one family in the early stages of the project had failed to establish), and that the two families established by the end of the first year had successfully reproduced.

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This project is supported through a partnership of Scottish Natural Heritage and the University of Oxford Wildlife Conservation Research Unit as part of the monitoring of the Scottish Beaver Trial. The authors thank the Royal Zoological Society of Scotland (RZSS), the Scottish Wildlife Trust (SWT), and Forestry Commission Scotland for their help and cooperation. RZSS and SWT have also contributed funds to the overall monitoring programme.

Table of Contents **Page**

1 INTRODUCTION

1.1 Background

The European, or Eurasian, beaver *Castor fiber* became extinct in Scotland around the 16th century as a result of over-hunting. Over recent years the potential for restoring this species to the natural fauna has been investigated. These investigations have resulted in a suite of information with regard to the scientific feasibility and desirability of conducting such a reintroduction. Relevant documents published by Scottish Natural Heritage (SNH) can be viewed at www.snh.gov.uk/scottishbeavertrial.

The work undertaken is in line with obligations on the UK Government, under Article 22 of the European Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna (the 'Habitats Directive'), to consider the desirability of reintroducing certain species (listed on Annex IV), including European beaver. No work is currently planned for the restoration of any other species listed in Annex IV of the Habitats Directive.

The Species Action Framework, launched in 2007 by Ministers, sets out a strategic approach to species management in Scotland. In addition, 32 species, including European beaver, were identified as the focus of new management action for five years from 2007. SNH works with a range of partners in developing this work and further information can be found at www.snh.gov.uk/speciesactionframework.

In May 2008, the Scottish Government Deputy Minister for the Environment approved a licence to allow a trial reintroduction of up to four families of European beaver into Knapdale Forest, mid-Argyll.

The licence has been granted to the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS), who are managing the 'Scottish Beaver Trial'. The trial site, Knapdale Forest in Argyll, is owned by Forest Commission Scotland (FCS). Several families of animals were caught in Norway during 2008 and quarantined for six months. Three families were released in spring 2009, and a further two pairs[1] in May and June 2010. The release sites were Loch Coille Bharr, Loch Linne/Loch Fidhle, Creagmhor Loch and un-named Loch (south), also known as the 'Lily Loch'. The release is being followed by a five-year period of monitoring that will run until Spring 2014. SWT and RZSS have dedicated field staff in place to cover this period.

One of the objectives of the Scottish Beaver Trial, as set out in the original licence application submitted by SWT and RZSS, includes the 'study of the ecology and biology of the European beaver in the Scottish environment', which will, in part, fulfil another of the objectives, to 'generate information during the proposed trial release that will inform a potential further release of beavers at other sites with different habitat characteristics'.

The licence issued by The Scottish Government to the RZSS and SWT came with a number of conditions, a key one being that the monitoring of the project must be independently coordinated by SNH. As part of this process, SNH has, therefore, entered a partnership with the Wildlife Conservation Research Unit (WildCRU) at the University of Oxford to support, enable and report on the ecological monitoring of the

[1] The fifth family was released, under agreement from the Scottish Government, as a replacement for the first family that failed to establish

beaver population and other riparian mammals[2] during the trial period. This is one element of a wider monitoring programme, coordinated by SNH, which includes:

- Beaver health
- Terrestrial vegetation
- Aquatic/ semi-aquatic macrophytes
- Fish
- Odonata
- Water chemistry
- Hydrology
- Riverine geomorphology
- Socio-economics
- Public health
- Scheduled monuments

WildCRU does not have a lead role with the other monitoring projects listed above, but the various elements are coordinated so that data can be efficiently collected and shared by those involved with the monitoring programme.

The licence application also sets out success criteria for the project, some of which are specific to the ecology of the beaver (rather than the wider socio-economic and other environmental aspects of the trial). These are:

- Survival of introduced animals is similar to that of successful reintroduction programmes elsewhere in Europe at a similar stage of population establishment.
- A stable or increasing core population is achieved within the limits of the study site.

There are also failure criteria, including:

- Mortality levels preclude establishment of a population.
- Significant and unsustainable damage is incurred by the ecosystem within the study site.
- The area suffers significant economic loss as a result of beaver activities.
- Costs of project/damage/management significantly exceed expectations.

1.2 Aims of the ecological monitoring project

The overall objectives of the Scottish Beaver Trial, and the success and failure criteria as set out in the licence application (above), were taken into account when identifying the aims of this monitoring project.

The over-arching aim of this project over five years is to contribute towards the development of a programme of 'essential' beaver and riparian mammal ecological monitoring work required to address the aims and success/failure criteria of the trial, and to ensure SNH will have access to suitable, independent information so that it

[2] The number of 'other riparian mammals' that we are able to monitor is limited by resources and therefore we chose to concentrate on the otter because it is a qualifying feature of the Taynish-Knapdale Special Area of Conservation (2.6 and Appendix B). We included American mink and water vole because field signs for these two species can potentially be detected while carrying out otter surveys, and thus without the requirement for additional resources. The water shrew is designated as a Species of Conservation Concern in the UK but we are not aware of any water shrew records from Knapdale so this species was not included in the monitoring programme.

can report to Scottish Government during and after the trial. More specifically, the initial aims were:

To produce standardised methodological protocols

(i) To produce methodological protocols in time for the release of beaver in spring 2009 for the monitoring of 'essential', key aspects of beaver ecology.

(ii) To produce an associated five-year work programme (spring 2009 – spring 2014), for the monitoring of 'essential', key aspects of beaver ecology.

(iii) To ensure the methodology includes the collation of suitable data which will allow the refinement of the existing beaver population model commissioned by SNH (Rushton *et al.* 2002), thereby improving our ability to predict future trends in beaver populations should the trial support the case for further reintroductions.

(iv) To produce a methodology which addresses other relevant mammal monitoring during the trial (in particular otter *Lutra lutra*, but also water vole *Arvicola amphibius*, and the invasive non-native American mink *Neovison vison*).

(v) To produce a detailed protocol for the field staff, which will guide them in the collection, storage and dissemination of beaver-related data during the trial, suitable for later analysis by WildCRU in liaison with SNH.

To produce annual reports:

(vi) To produce annual reports, and other relevant outputs, on the results of monitoring of beaver ecology, using data/information received from the Field Officer staff and other project workers.

To produce an 'end of trial' report:

(vii) To produce a report, and other relevant outputs, at the end of the trial on the results of monitoring of beaver ecology, covering the entire trial period.

The standardised methodological protocols were written by Ruairidh Campbell *et al.* and were published by SNH in 2010 as *Campbell et al. (2010). The Scottish Beaver Trial: Ecological monitoring of the European beaver and other riparian mammals – Initial methodological protocols 2009. SNH Commissioned Report No. 383*[3]. Field tracking of the beaver population, including trial use of various telemetry methods, and trapping of the animals, is undertaken by SBT staff as part of the management of the release population. However, at the same time, SBT were asked to collate ecological data, following the standard methodological protocols set out in Campbell *et al.* (2010), to be used by SNH and WildCRU for the independent ecological monitoring. SNH are undertaking the otter monitoring. This report is the second of the

[3] Referred to hereafter as Campbell *et al.* (2010)

five annual reports on the ecological monitoring of the beaver[4]. The third annual report will be due in winter 2012.

In order that beaver welfare issues are properly addressed, and are balanced with the need to meet the aims of this project and the overall trial objectives, some broad principles were applied in developing the monitoring protocols. Tracking methods will always involve some level of disturbance to the animals. The methods appropriate for Knapdale were selected as the minimum necessary to address the beaver ecological monitoring requirements. The broad principles are:

- The welfare of the beavers during the trial is a priority. Animal welfare is being monitored by the relevant veterinary specialists (both those based at the RZSS and the independent specialists based at the Royal (Dick) School of Veterinary Studies) and will be kept under continuous review throughout the trial.
- Disturbance of the beavers, and the use of invasive tracking methods, is kept to a minimum to allow behaviour to be as natural as possible, and to allow successful establishment of the animals in the trial area. This, however, has to be balanced with the need to track beavers for scientific monitoring and management purposes.
- Tracking methods are being constantly reviewed by RZSS/SWT, SNH and WildCRU, and will be throughout the trial, to take account of ongoing experiences, and the development of technical advances.
- Results of ecological monitoring work will be published to allow open debate of the relevant issues.

1.3 Key information required

Campbell *et al.* (2010) identified the following key information that is needed to address the project aims:

- Population change of beavers (number of animals) during the trial.
- Beaver fecundity.
- Beaver mortality (and their causes).
- Population density.
- Age structure of the beaver population.
- Number and size of territories.
- Sociality of the beaver population (i.e. family structure and territory ownership).
- Dispersal by sub-adults.
- Movement within and outwith the trial area.
- Territory location (in relation to environment and to other territories).
- Habitat selection by beaver individuals within territories.
- Habitat selection by other riparian mammals.

The initial monitoring protocols were written with the aim of collecting this key information by undertaking six tasks that interlink with each other and, to some extent, with other Scottish Beaver Trial monitoring projects: trapping, observations, radio-telemetry, Argos-telemetry, and field sign surveys for beavers and field sign surveys for other riparian mammals. Although the monitoring protocols included an element of cross-over with some of the tasks (i.e. one task may collect some of the

[4] The first annual report was published by SNH in 2011 as *Harrington et al. (2011) The Scottish Beaver Trial: Ecological monitoring of the European beaver* Castor fiber *and other riparian mammals – First Annual Report 2010. SNH Commissioned Report No. 450*

same information as another task), this apparent redundancy was considered essential because one task may not provide the desired information in all situations.

This report outlines the ecological monitoring methods that are being carried out and presents early results on the ecology of the released beavers and other riparian mammals at the end of the second year of the Scottish Beaver Trial (June 2011).

In ensuring that the relevant key information is collected, the aim throughout is to achieve a balance between data collection, animal welfare and maintaining natural behaviours within the population.

1.4 Reviewing of methods

Over the first year of the trial some changes were made to the original monitoring protocols as specified in Campbell *et al.* (2010) and these were outlined in the first annual report (see Harrington *et al.* 2011). During the second year of the project, preliminary trials investigating the potential use of inexpensive GPS transmitters indicated that GPS tracking would be a useful monitoring tool. Therefore, further amendments have been made to the ecological monitoring methods, including a renewed emphasis on radio-telemetry (GPS) and, accordingly, decreased emphasis on observational methods (put in place in 2010 as a replacement for VHF telemetry). Field sign surveys continue to provide essential ecological information and provide continuity for the data collected thus far. In addition, we propose the use of depth-temperature recorders (DTRs) to provide further information on aquatic habitat use by beavers. SNH and WildCRU will continue to review these methods throughout the trial, in close discussion with SBT, and any further changes will be identified in future reports.

2 FIELD METHODS

Inevitably a number of issues with the proposed monitoring methodology were identified during the first year of the project. As a result, some amendments to the published monitoring protocols in Campbell *et al.* (2010) were necessary; these amendments were reported fully in Harrington *et al.* (2011). In this section, we describe the methods used in Year 2 of the project, according to the final monitoring protocols as discussed and agreed with SBT in January 2011. Year 1 methods are also described where appropriate, and where these differ from Year 2 methods, for any data that are used in current analyses.

The most significant amendment to the published monitoring protocols was the discontinuation of radio-telemetry (see Harrington *et al.* 2011). VHF telemetry is not reported on further in the current report. For the current analyses, there was an increased emphasis on the use of observational methods and field sign data. A trial use of GPS telemetry is described and its future implementation discussed (4.2).

2.1 Animals released

A total of fifteen beavers in five families or pairs were released in Knapdale during the first year of the project (Table 1, Figure 1); the first three families were released in May 2009, a fourth pair was released later in May 2010. A fifth pair was released in June 2010 as a replacement for the loss of family 1, and one additional male was released during the second year of the project, in September 2010, as a replacement for an individual that had died soon after release (Table 1). The aim of the latter two releases was to establish a minimum of four potential breeding pairs within the release area (see Fig. 1) by May 2011[5]. Thus far, a total of 16 beavers have been released. There are no plans to release more beavers in Knapdale for the duration of this trial, in accordance with amended licence conditions (see footnote 5).

[5] Scottish Government granted permission for the replacement of dead or dispersed adult beavers for the period up to May 2011

Table 1. Beavers released in Knapdale, Argyll, May 2009 – September 2010

Name	Sex	Age[a]	Family	Release data	Release loch	Fate (as of June 2011)
Andreas Bjorn	M	5+	1	31/05/2009	Creaghmhor	Withdrawn from programme Dec 2009; died in captivity May 2010
Gunn Rita	F	5	1	31/05/2009	Creaghmhor	Missing[b]
Mary Lou	F	1	1	31/05/2009	Creaghmhor	Missing[b]
Frank	M	Unknown	2	30/05/2009	Loch Linne	Alive
Frid	F	Unknown	2	30/05/2009	Loch Linne	Alive
Biffa	M	2	2	30/05/2009	Loch Linne	Missing[c]
Biffa's brother	M	2	2	30/05/2009	Loch Linne	Dead (shortly after release)
Bjornar	M	Unknown	3	30/05/2009	Loch Coille Bharr	Alive
Katrina	F	Unknown	3	30/05/2009	Loch Coille Bharr	Alive
Mille	F	2	3	30/05/2009	Loch Coille Bharr	Alive
Marlene	F	2	3	30/05/2009	Loch Coille Bharr	Missing[c]
Tallak	M	5+	4	04/05/2010	Un-named (S) or 'Lily Loch'	Dead (approx 2 weeks post-release)
Trude	F	2	4	04/05/2010	Un-named (S) or 'Lily Loch'	Alive
Eoghann	M	2	5[d]	23/06/2010	Creaghmhor	Alive
Elaine	F	2	5[d]	23/06/2010	Creaghmhor	Alive
Christian	M	3	4[f]	21/09/2010	Loch Buic[f]	Alive

[a] Estimated age at the time of release

[b] Gunn Rita disappeared in the second week post-release, her female kit disappeared in mid-July 2009 - see 3.5.2 (below)

[c] Biffa was last seen in February 2011

[d] Marlene was observed fighting with another family member in June 2009 (in the first month post-release); telemetry signals suggested that she was on a nearby sea loch in August 2009, but this was not confirmed visually (she has not been seen since) - see 3.5.3 (below)

[e] The fifth pair of beavers was released as a replacement for the loss of Family 1 with the aim of establishing a minimum of four potential breeding pairs in the release area by May 2011.

[f] Christian was released to provide a mate for Trude following the death of Tallak; he was released into Loch Buic where Trude had established a small burrow and was regularly observed feeding. (Christian was released at the far end of the loch at an artificial lodge where his scent had been placed prior to release - the two beavers paired up on the night of Christians release and remained together until the end of Year 2[6]).

[6] Preliminary results from Year 3 suggest that some inter-pair movements have occurred between the two pairs of beavers (Family 4 and 5) - Eoghann appears to have moved to Loch Buic and to have paired with Trude. These inter-pair movements will be reported on in detail in next years report.

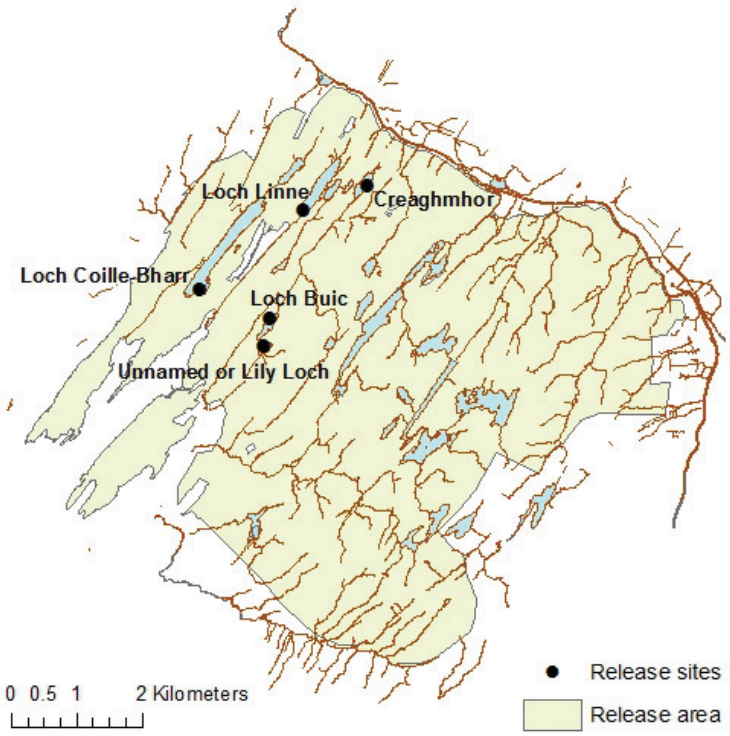


Figure 1. Location of initial beaver releases, Knapdale, Argyll, May 2009 – September 2010 (see Table 1).

2.2 Trapping

SBT aimed to trap all animals at least once per year for health checks, and to replace tags as necessary, between late summer and early autumn. For welfare reasons, appropriate actions were taken to avoid repeated capture of the same individuals (see Appendix A), and non-target cage traps (see below) were not used between late February and late spring to avoid capturing pregnant females in traps. Annual trapping provides information on annual survival of known individuals, body condition of released beavers, reproductive rates (number of females breeding and number of kits per breeding female), population size, and density within the release site, age structure of the population, family sizes and composition, and some indirect information on the number or proportion of animals dispersing[7]. Health checks are carried out as part of the trial management. Here, we report basic measures of body condition, but detailed data on the health of the beavers at Knapdale will be reported on by the relevant independent monitoring partner, the Royal (Dick) School of Veterinary Studies elsewhere.

[7] Whether dispersal is 'natural' dispersal of young sub-adults leaving the parental group , or 'dispersal from the release site' by newly-released adults, the proportion of animals dispersing can only realistically be estimated from the disappearance (lack of captures and observations) of animals from the site. Further, in the event of a disappearance, it will not always be possible to determine whether the disappearance was due to dispersal or to mortality. Some information on minimum distances moved will be obtained from reports of field signs outside the release area

Additionally, attempts were made to trap and mark all wild-born kits in their first year.

Where possible, trapping was by boat (following methods used in Norway; Rosell and Hovde 2001); in smaller lochs where the use of boats was impractical, Bavarian cage traps were used. The preferred technique is the Norwegian method of trapping from a boat because it allows targeted captures, and reduces individual recaptures and overall capture time. Trapping from a boat is currently possible on Loch Linne, Loch Buic and Creagmhor. Whilst cage trapping on Dubh Loch (a small loch neighbouring Loch Coille-Bharr) has been successful for capturing adults, it remains problematic for catching wild-born young that appear to be trap-shy (thus far, the wild-born yearling on Dubh Loch[8] has not been caught – see Results).

During capture, standard morphometric measures of beavers were taken, ear-tags (modified by applying coloured reflective tape to aid visual identification of beavers in the field) were fitted (if lost, or if the animal was not already marked) and samples were taken. Nipple size of female beavers was measured as an indicator of reproduction – nipples significantly larger than 0.5 cm may indicate that the female is pregnant or lactating (Müller-Schwarze and Sun, 2003; Campbell *et al.* 2010). Samples collected included hair and faecal samples, castoreum and anal gland secretion, and blood samples. Some of these samples will not necessarily be a part of the essential monitoring but may be used for 'non-essential' research by other parties[9].

During Year 1 of the project, trapping was carried out in December 2009, February-March 2010 and May 2010. During Year 2, trapping was carried out monthly (at one or two lochs per month) with the aim of trapping all individuals at least once over the year (Table 2).

[8] Family 3, originally released on Loch Coille-Bharr, have moved on to the smaller neighbouring Dubh Loch

[9] Decisions on the use of the samples will be discussed and agreed by members of the Scottish Beaver Trial Research and Monitoring Coordination Group as appropriate.

Table 2. Trap effort within the release area, May 2009 – June 2011

Dates	Site	N traps	N hours	Total trap hours[a]	N nights boat trapping	New captures	Recaptures
1st YEAR							
23/11/2009-11/12/2009	Loch Linne	2	108	182	1	3	0
23/11/2009-11/12/2009	Creagmhor	-	-	-	2	1	1
01/02/2010-24/03/2010	Dubh Loch[b]	2	220.5	386.5	-	1	1
May 2010[c]	Dubh Loch	?	?	?	?	0	1
2nd YEAR							
October 2010	Creagmhor Loch Linne	- -	- -	- -	2 2	1 1	1 0
November 2010	Dubh Loch	2	46.5	86	-	1	0
December 2010	Dubh Loch Loch Linne	1-2 2	67 19.5	85.5 39	- -	0 0	0 0
January (26) – March (16) 2011	Dubh Loch	2	223	438	-	1	2
February 2011	Loch Linne	-	-	-	2	1	0
March 2011	Loch Linne	-	-	-	5	2	1
April 2011	Creagmhor Loch Linne	- -	- -	- -	3 1	2 0	0 0
May 2011	Dubh Loch Loch Linne	2 -	11.5 -	23 -	- 1	0 1	0 0
June 2011	Loch Coille-Bharr Loch Linne	- -	- -	- -	1 1	1 1	0 0

[a] corrected for tripped traps
[b] a small loch to the south of Loch Coille-Bharr
[c] trap session abandoned to avoid recapturing the female at Dubh Loch during the potential pregnancy period.

Prior to the main trap sessions, during the first year of the project, two ad hoc trap events were carried out outwith the trial area: one on the Crinan Canal (06/07/2009, 1 trap set for 48 hours) and one at Kilmartin Fish farm (12/08/2009, boat trapping), in an attempt to recapture the three beavers in Family 1 that had left the release site (see Table 1). The adult male of the family (Andreas Bjorn) was successfully recaptured and returned to his release site (Creagmhor)[10]. The attempt to recapture the two females on the Crinan Canal failed.

[10] This animal was recaptured in poor body condition during the December 2009 trap session, the decision was made to return him to captivity where he died in May 2010.

2.3 Observations

2.3.1 Locational observations

Observations of beavers were recorded during monthly visual checks carried out by SBT for management purposes. Locations of all animals observed were recorded and, where possible, animals were identified. The recording of observational data serves as a non-invasive alternative to repeat trapping of animals and observations of identified individuals can thus provide additional information on the fate of released animals. In a more formal analysis, observations of identified animals can be considered analogous to 'recaptures' in a capture-mark-recapture (resight) analysis and used to estimate survival rates or population size. Because radio-telemetry was found to be impractical at Knapdale (Harrington *et al.* 2011), observational locations of beavers were also used instead of radio-telemetry 'fixes' to determine territory (home range) sizes and to give an indication of habitat use. Territory sizes and habitat use were analysed at a family level and therefore, locations of both identified and unidentified beavers were included (this was possible, because at Knapdale, families occupied different lochs in separate and quite discrete locations – see Fig 8). The use of observational locations in analyses of home range size or habitat use are potentially subject to bias because animals are most often observed on the water and cannot be seen through the thick vegetation when they are ashore, biases were, however, overcome to some extent by combining observational locations with field-sign locations (below, 2.4).

Observations were carried out with the aim of watching each family over a full night (8 hours) each month (although in practice, a 'full night' was sometimes split over two nights, one covering the first half of the night and one covering the second). Lochs were searched systematically by boat and the locations and identity of all beavers seen recorded. Repeat searches of the loch were continued through the night, with the aim of recording locations of each individual in the family, or pair, of beavers, approximately once per hour. If an animal was moving when it was observed (and deemed not to be moving in response to the presence of the observers) successive locations were recorded at distances of 10 m or more apart (at variable time intervals as appropriate and according to the speed of movements). On the smaller lochs, where systematic searching by boat was not feasible (or necessary), observations were made from either a static hide, or a boat, at suitable vantage points. Spotlights were used for observations in the dark, following earlier efforts to habituate beavers to the lights.

Note that intensive observational tracking will no longer take place in Year 3 of the project (see Appendix A), although a single monthly location for each animal will be recorded to verify survival and broad animal locations.

Behavioural observations were attempted in the first year of the project but proved to be problematic because newly-released beavers appeared to be disturbed by the presence of observers and/or the lights used by observers. Since the behaviour of newly-released beavers is also likely to differ in unknown ways from 'normal' behaviour of established animals, behavioural observations were not carried out in Year 2 of the project. However, as beavers become habituated to observers and lights, and settle in the release area, focal observations should become possible, as well as more representative of 'normal' behaviour and detailed behavioural studies of established beavers may, therefore, be introduced in later years. Detailed behavioural data are supplementary to the essential ecological data currently being collected, but would be extremely valuable in further understanding the ecology of reintroduced beavers and may help to explain the ecological results obtained. The

need for and the feasibility of focal behavioural observations will become apparent as the project progresses and will be reviewed and the practicalities discussed with SBT at a later date.

2.3.2 Lodge/den counts

Note that these methods were agreed in January 2011 and therefore not carried out in Year 2 of the project, but were implemented in Year 3.

In addition to monthly systematic observations of all beaver families, weekly observations of active lodges and dens of mated pairs were carried out (from a fixed location) when the emergence of kits was expected (from approximately mid-July, through September). Lodges/dens were observed at dusk, from the time that the beavers first emerged in the evening, and continued until the light faded and observers were unable to see beavers clearly. During these observation periods the number of animals seen (classified as adults, yearlings and new kits) at the lodge or den were counted. Lights were not used initially to avoid scaring the kits, but were used in September.

Following methods and recommendations in Rosell *et al.* (2006), the final 'beaver count' for each family was based on the maximum number of beavers counted on any one night. Trends in counts over successive weekly counts were examined to determine the optimum number of repeat weekly counts required in future years to increase the accuracy and precision of the data. Similarly, to enable refinement of the methodology, the time of all observations was recorded. Observation periods initially were approximately 19.30 – 22.00 hours but will be adjusted if necessary in future to maximise the chances of observing beavers emerging from the lodge or den, and specifically, the chances of observing kits emerging[11].

In Year 2, each of the two lochs with resident beaver families was observed over one or more nights, for 2 hours (at dusk and until it was too dark to see) at approximately weekly intervals (n=9 or 10 observation periods in total per loch). In this case, systematic counts of individual beavers emerging from the lodge or den were not carried out but kits seen with adults during normal observational searches of the loch (as above) were recorded[12].

2.4 Field sign surveys

Field sign surveys were carried out on foot, or by boat, along loch and river banks, recording all observed field signs (see Table 3) and their locations. The aim was to locate (1) dams, lodges and dens, (2) areas of high foraging activity and (3) likely territory borders (if any). For feeding signs, only fresh signs (i.e. those left within the last three months) were recorded; for other field signs (e.g. lodges, burrows, or scent mounds), only those with evidence of recent (within the last 3 months) use were recorded. Field signs were marked with natural wool to enable surveyors to distinguish fresh from older, previously recorded, signs in successive surveys. Signs of the same type were recorded only once per 10 m of loch or river bank. Dams were photographed. For all surveys, search effort (time spend surveying) was recorded. Surveys were carried out seasonally. All riparian habitat in areas known to contain beavers were searched each season covering an area up to 40 m from the water's edge (Fig 2).

[11] Note that the duration of observations has been increased for Year 3 – see Appendix A.

[12] No kits were expected in Year 1 because beavers were not released during the mating season and females were not pregnant on release.

These methods were based on agreed protocol amendments in January 2011. Previously, through Year 1 and the summer and autumn of Year 2, field sign surveys were carried out monthly but covered only 5 m from the water's edge (a larger area, covering up to 40 m from the water's edge was searched seasonally). Amendments were also made to the information recorded to avoid unnecessary overlap with the woodland monitoring work; for example, information on the species or size of trees cut or gnawed by beavers is no longer recorded. Moore *et al.* (2011) report on selection by beavers for particular tree species and size. The change in methods means that the number or density of field signs cannot be compared between Year 1 and Year 2 of the project. The important aspect of these data for current analyses, however, are their locations; numbers of field signs per se are not currently relevant beyond ensuring that there are a sufficient number of locations to provide robust estimates of home range size.

Table 3. Field signs recorded (revised January 2011)

Type	**Feature**	**Including**
Dwelling	Burrow	
	Lodge	
Construction	Dam	
	Canal	
Feed Sign	Food cache	Underwater stores of cut saplings and branches outside the lodge/burrow
	Tree/branch cutting	Felled trees/saplings Cut tree stumps Gnawed trees Cut branches Stripped branches/sticks
	Feeding stations	
	Foraging trail	
	Other	Grazed area = cropped (by beavers) ground vegetation Acquatic macrophyte mats
Activity	Tracks	
	Scent mound or marking	Single mark, or recent marking of a larger, frequently used mound etc.

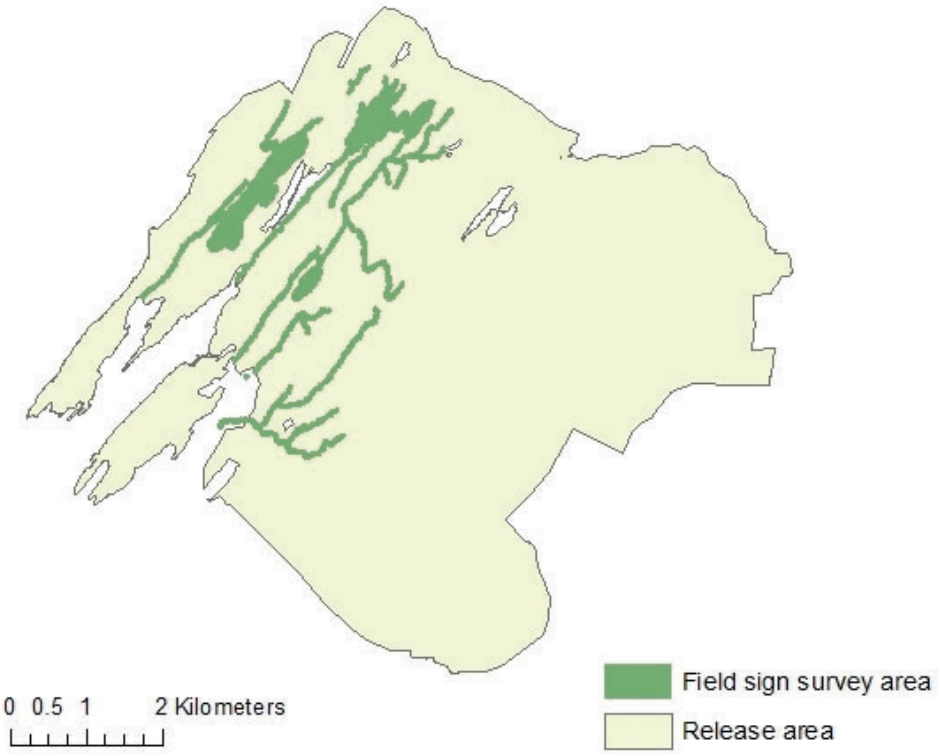


Figure 2. Areas surveyed for field signs within the release area (based on a 40 m buffer around each loch occupied by beavers), Knapdale, Argyll. Since January 2011, these areas have been surveyed seasonally (in Year 1, a smaller area – based on a 5 m buffer – was surveyed monthly – see text).

Assessment of habitat use based only on field signs is biased towards use of woody vegetation (there are few obvious signs of foraging on herbaceous or aquatic vegetation), but field signs can be used to supplement other more difficult, labour intensive or expensive methods (e.g. direct observations, GPS telemetry or depth-temperature recorders, DTR's) to provide a more complete picture of beaver foraging-habitat use (as above).

In addition, anecdotal reports of field signs outside the release area were recorded to provide information on dispersal.

2.5 GPS telemetry trial

In an attempt to investigate alternative affordable replacements to the discontinued radiotelemetry, SBT proposed a trial to assess the feasibility of using inexpensive GPS transmitters (i-Got-U tags) sold commercially as 'route trackers', to monitor animal movements. Tags were fitted to two beavers for a period of eight to nine days and eight static tests were carried out as a preliminary investigation of the accuracy of the method. Further methodological details will be included in next years report.

2.6 Surveys of otters and other riparian mammals

One of the qualifying features of the Taynish-Knapdale Special Area of Conservation (SAC) is the Eurasian otter (*Lutra lutra*) (which is also a UK BAP priority species and a European Protected Species). To demonstrate that the trial reintroduction of beavers into the SAC will not negatively impact on the site's qualifying features or on

UK BAP priority species, otter presence in the area will be monitored over the duration of the project.

Survey methods were based on Strachan (2007) and were undertaken by SNH. Surveys were carried out within the release area and, for comparison, in a separate and independent control area (of similar habitat to the release area but located far enough outside the release area to minimise the chance of a single otter territory overlapping both the release area and the control area). Supplementary data on the presence of mink field signs (and water vole field signs) were also recorded. Further additional data on the presence of mink were provided by SBT from their mink control activities.

Twenty 100 m linear sites (10 in the release area and 10 in the control area) were surveyed annually in the autumn (mainly October and November). Survey sites were selected amongst three broad habitat types (inland watercourse, freshwater loch outflow, coastal watercourse outflow/shoreline) see (Harrington *et al.* 2011), with the additional specification that the two national otter survey sites within the release area – unnamed burn near Gariob Cottage, OS grid ref. NR781891 and the burn near Loch Barnluasgan, OS grid ref. NR789910 – were included amongst the ten sites to allow the use of survey data from earlier national otter surveys. The same sites were surveyed each year (Fig 3).

Figure 3. Otter survey sites within the release area (shaded), Knapdale, Argyll. The same sites are surveyed each year. 10 additional 'control' sites are surveyed outside the release area. See Appendix B.

Sites were surveyed by searching the entire length of the 100 m site and recording the following field signs: sightings (actual animals seen), total number of otter

spraints, number of otter resting places, presence of tracks/runs etc., total number of mink scats found, presence of mink tracks, other evidence of mink (including local reports), total number of water vole latrines, presence of water vole burrows and feeding signs. Whilst the original intention had been to collect spraints for potential further analysis, the number of spraints encountered during the first survey in Year 1 was low and spraints were rarely suitable for DNA analysis. Thus, the potential usefulness of samples for future non-essential research is limited. Spraints and scats were, therefore, collected only if species identification was uncertain in Year 2. Full details of the survey design are given in Appendix B. These expand on the details provided in Campbell *et al.* (2010).

Spraint surveys are not suitable for assessing habitat use by otters but were considered sufficient to monitor for broad changes in otter presence, distribution and relative abundance.

3. ANALYSIS AND RESULTS

This section describes and summarises data that were collected during the first two years of the trial (30th May 2009 – June 2011), and presents preliminary analyses of beaver ecology. Because two of the beaver families/pairs had been released for only one year (or less) at the time of writing this report, individual beavers are at different stages post-release and thus analyses (in some cases) differ among families/pairs.

In addition to presenting preliminary data on the establishment of beavers at Knapdale, a secondary aim of these analyses was to assess the quality and suitability of the data collected thus far, specifically with regard to amendments made to the original monitoring protocols during the first year of the trial.

3.1 Survival

Three deaths were recorded during the first year of the trial (Table 1). A further three animals were also classified as 'missing' (fate unknown) by the end of the first year (Table 1). No further deaths were recorded during the second year of the trial but one further animal was recorded as missing. As of June 2011, of the 16 animals released over 2009 and 2010, nine were believed to be alive and present in the release area (plus two wild-born yearling animals born in 2010 – below).

Three known deaths in the first year of the trial were all males (Table 1, 4). Andreas Bjorn was found in poor body condition and withdrawn from the programme in December 2009 (7 months post-release) and died five months later in captivity of heart failure. Tallak died a couple of weeks post-release and post mortem results suggest that he did not feed, most likely due to an individual failure to cope with the stress of change in environment (S. Girling, RZSS, pers. comm.). Andreas Bjorn and Tallak were both older males (age estimates based on cementum analysis of their teeth are pending). The only younger (2 year old) male to die post-release, died overnight on the day of release; this animal was found to have lung, liver and kidney congestion suggestive of sub-acute circulatory failure[13] (R. Campbell-Palmer, pers. comm.). Beaver health is being monitored by the Royal (Dick) School of Veterinary Studies, and further details will be available in a separate report at a later date.

Table 4. Beaver deaths by age class, 2009-2011

Sex-age class	**Recorded deaths (n, %)**	**Cause of death**
1 year olds	0	-
2 year olds	1 (14)	Circulatory failure (see text)
Adult females (3 years +)	0	-
Adult males (3 years +)	2 (50)	Heart failure (Andreas Bjorn) Lost body condition post-release – stress related? (Tallak)

The first missing animals were a mother and daughter that disappeared in June-July following their release; the other two missing animals were both subadults (one female and one male) that were at an age at which they would be expected to leave their family group (Müller-Schwarze and Sun 2003). These two animals were monitored, prior to their disappearance, for 3 months, and for 1 year and 10 months, post-release, respectively; both were 2 years of age at release.

[13] There was no evidence of infection or degenerative disease (R. Campbell-Palmer, pers. comm.)

Known overall survival, as of June 2011 (2 years after the initial release), was 45% for those animals released in 2009 or 56% for all animals released. Note, however, that (1). the latter figure is not the same as a two year survival rate because not all animals had been released two years ago, and (2). that the figures presented here are minimum survival rates because missing animals are, for the purpose of these calculations presumed dead (or not part of the surviving population). Approximate minimum survival rates for different periods of the release are given in Table 5. In future years, formal survival rates will be calculated using the Kaplan-Meier method (Kaplan and Meier 1958), using the staggered entry design, which can incorporate different release dates as well as 're-sighting data' obtained from a variety of different sources (e.g. trapping and observational data). As more and longer-term data, on both survival and reproductive rates, become available over the course of the project, formal comparisons will be made with comparable rates reported in other beaver reintroductions in Europe. These analyses will be reported on in later reports.

Table 5. Approximate minimum survival rates over the course of the release, 2009-2011.
Note that these are approximate rates only because not all animals were released at the same time (i.e. at the end of the first year, 11 animals had been in the wild one year, 2 had been in the wild 1 month, another 2 only a week), and minimum rates because missing animals are not counted as part of the surviving population.

Period since release	No. animals released	No. still alive at end of period	Survival %
1 month	11	9	82
3 months	11	8	73
1 year	15	9	60
2 years	16	9	56

3.2 Morphometrics and body condition

Pre- and post-release morphometric data were available for six individuals (excluding Andreas Bjorn withdrawn from the programme[14]) (Appendix C). Pre-release data were missing for two individuals; two individuals have not yet been captured post-release (although they are regularly observed). For those animals that were captured and measured, all either maintained their body weight or gained weight (median weight gain = 2.5 kg, max = 7.3 kg) in the first year post-release ($W=15.0$, $p=0.03$, $n=6$, one-tail test). There was no statistically significant increase in body length, tail length or tail width, nor was there any statistically significant change in tail thickness post-release ($p>0.05$, $n=5$ in all cases, Table 6) during the first year. At the time of writing this report, morphometric data two years post-release were only available for three individuals (four individuals were only released one year, or less, ago), therefore, changes at two years post-release will be investigated in the next annual report.

[14] This animal lost 0.6 kg in the first 2.5 months post-release, and a total of 2 kg by six months post-release – at this time the animal was assessed as in poor body condition and withdrawn from the program

Table 6. Pre-release and 1 year post-release morphometric data for six beavers released in 2009 and 2010.
Data are pre-release, post-release values; medians are given for sex-age classes with n>1. Post-release measures were taken at 6.5 or 10 months post-release. Animals for which there are no pre-release data are not shown. See Appendix C.

Sex-age class	N	Body length (cm)	Tail length (cm)	Tail width (cm)	Tail thickness[a] (cm)	Weight (kg)
Adult female[b]	2	77.5, 77	28.7, 29	8.5, 9	2.33, 2.43	17.7, 21.2
Adult male	1	77, 78	30.2, 29	8.6, 10.5	2.36, 1.70	12.1, 19.4
2 year old male	2	69.5, 71.8	26.9, 27.4	8.9, 9.5	1.59, 1.66	12.3, 13.8
2 year old female	1	71, 69	25.2, 25.5	9.0, 8.7	1.67, 1.77	12.5, 13.5
Pre-Post release difference[c] (W, p, n)		7.0 1.0 5	9.5 0.686 5	11.0 0.418 5	10.0 0.59 5	**15.0** **0.03** **6**

[a] Measured as the mean of four separate measures taken from four standard points on the tail (details in Campbell *et al.* 2010)
[b] Pre-release data only available for one of the adult females (except for weight which was available for both)
[c] Wilcoxon signed rank test; test for weight was two-tailed, all others were one-tailed. W is the Wilcoxon signed rank test statistic, p is the probability value ($p \geq 0.05$ is accepted as statistically significant)

3.3 Reproduction

The initial release took place after the mating season, and females were not released pregnant, therefore, no reproduction was expected in Year 1.

In August 2010, two kits were observed during observations, one at Loch Linne (Family 2) and the other at Dubh Loch (Family 3) in August 2010. Counts of beavers emerging from the lodge or den were not made, but one kit per family was inferred on the basis that only one kit was ever seen with an adult at any one time. Reproduction was not expected at Lily Loch (Family 4) or Creagmhor (Family 5) in 2010 because both pairs were released after the 2010 mating season. The female from Dubh Loch (Katrina) also had enlarged nipples when she was trapped in October 2010 (Table 7), confirming that she had been lactating.

One wild-born male yearling, born in 2010, was captured and marked on Loch Linne in June 2011 (Table 7). At one year of age, this individual weighed 8.4 kg and had a body length of 59 cm (tail length = 22 cm, tail width = 7 cm, tail thickness = 1.48 cm). SBT were not able to capture the other yearling, also born in 2010, at Dubh Loch. Four separate trap sessions were carried out at Dubh Loch in Year 2 (seven trap sessions were carried out at Loch Linne); however, trap methods differ between the lochs because it is not possible to use the preferred boat trapping method at Dubh Loch. Although, overall capture success appears to be similar at the two lochs (Table 2), the limitation of cage trapping is the inability to target particular animals. As might be expected, the wild-born yearling appeared to be considerably more trap-shy than either of the released adults at Dubh Loch (R. Campbell-Palmer, pers. comm.). Both wild-born young were, however, observed frequently over the year; the Dubh Loch yearling was last seen in May 2011 (Table 7)and appeared to be healthy and behaving normally. Both young born in 2010 survived to one year.

In 2011, three females (on Loch Linne, Dubh Loch and Creagmhor) (Family 2, 3, and 5, respectively) had enlarged nipples (Table 7), indicating that they were likely

pregnant. The female on Lily Loch/Loch Buic (Trude, Family 4) was not captured but observations and BBC film footage[15] suggested that she was also pregnant[16].

Table 7. Reproductive data or information available, June 2009 - June 2011

Family	Female with enlarged nipples	Observation effort during emergence time	Observations of wild-born young	Lodge or den counts	Wild-born young trapped
2009					
Family 2 (Loch Linne)	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Family 3 (Dubh Loch)	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Family 4	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Family 5	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
2010					
Family 2 (Loch Linne)	**(not checked)**	**9 loch observations at weekly intervals**	**First obs 3/8/2010 Last obs 19/5/2011**	**N/A**	**20/6/2011 (marked)**
Family 3 (Dubh Loch)	**Yes (October)**	**10 loch observations at weekly intervals**	**First obs 9/8/2010 Last obs 19/5/2011**	**N/A**	**4 trap sessions – NOT trapped**
Family 4	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Family 5	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
2011					
Family 2 (Loch Linne)	**Yes (March)**	**DATA NOT YET AVAILABLE**			
Family 3 (Dubh Loch)	**Yes (March)**				
Family 4 (Lily Loch/Loch Buic)	**(Female not captured)**				
Family 5 (Creagmhor)	**Yes (April)**				

3.4 Home range / Territory sizes

To estimate territory size we used both observational locations and field sign locations. At the time of writing this report, two families had been released two years previously, two other families (released as pairs) were released only one year ago. Territory sizes were estimated at the family level; we did not estimate individual territories (see Harrington *et al.* 2011).

Family 4 and Family 5 were released a year later than Family 2 and 3, therefore, the following analyses include Family 2 and 3, one and two years post-release, but

[15] Available during filming for the BBC's Springwatch program, in May 2011.

[16] Reproductive data from summer 2011 is part of Year 3 of the project, and will be reported on fully in the next annual report; preliminary observations suggest that two families have produced one kit each (one of these kits was killed by a predator and partially eaten).

Family 4 and 5 only one year post-release. Further, the male beaver (Christian) was released over 4 months after the female (Trude). In the following analyses, we consider Trude's release date as the beginning of the first year for this pair. It may, however, be more appropriate in future analyses to consider the date of Christian's release as the beginning of the first year. Similarly, we present below analyses of the home range of Family 5 one year post-release but note that this pair was released towards the end of June 2010 (Table 1) and therefore, their first year is not quite complete. Home range estimates for the latter two 'families', therefore, are preliminary.

For the first few months after release observational data may be affected by the presence of observers and lights. There were also inconsistencies in the recording of field sign data in the first few months of the project. SBT advise that prior to March 2010 not all field signs were recorded and therefore, winter and spring data may include old field signs from earlier seasons. For these reasons, we have investigated seasonal territories only for Year 2 of the project. For the purpose of analysis, seasons were defined as follows: Summer = June, July, August, Autumn = September, October, November, Winter = December, January, February, Spring = March, April, May.

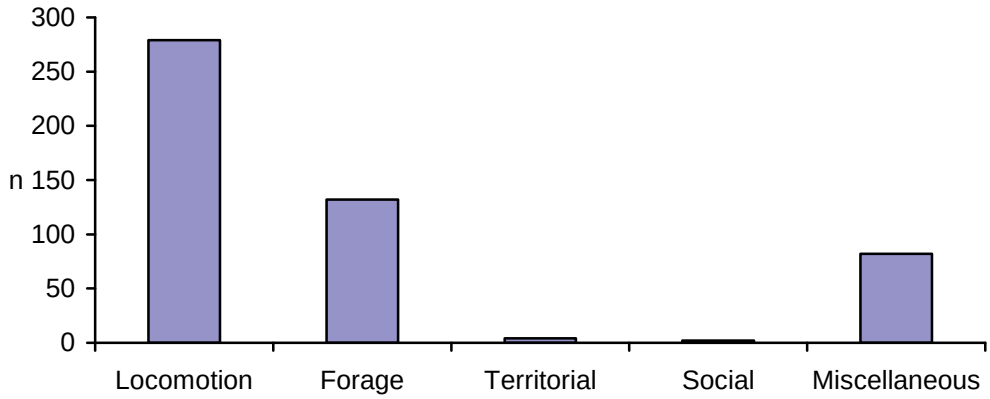
3.4.1 Observational data

Over two years, a total of 2003 beaver observations were recorded (522[17] in Year 1, 1481 in Year 2); 1050 of these were of identified individuals (393 in Year 1, 657 in Year 2)[18]. The number of observations were similar for all families (Table 8, 3.4.3 below).

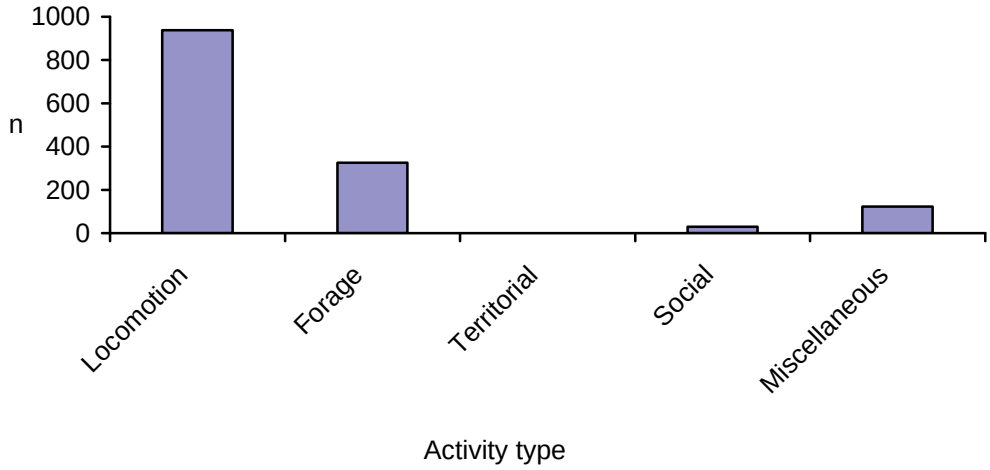
In Year 1, most observations were of swimming beavers, but foraging was also observed; territorial and social behaviour only rarely (Figure 4a). During most foraging observations, beavers were seen feeding on woody vegetation; feeding on aquatic and herbaceous vegetation was observed in 13 (10% of all foraging observations) and six (5%) cases, respectively. Four observations of beavers scent marking were recorded; beavers were not seen fighting or using stick displays. Social observations were limited to two occasions on which beavers were seen allogrooming[19]. Beavers were not seen building dams or lodges (although clearly considerable building activity took place – see Fig 7).

The distribution of types of observation in Year 2 was broadly similar to Year 1 (Fig 4b). Interestingly, there was an increase in the proportion of aquatic foraging observed: 25% of foraging observations were on aquatic vegetation, 72% on woody vegetation and 3% on herbaceous vegetation. Whether or not increased observations of aquatic foraging were due to actual changes in beaver foraging behaviour or due to increased habituation of beavers, however, is not clear. There was also a slight increase in the number of social observations recorded, including 12 observations of nose-to-nose interactions[20], ten observations of wrestling[21], and seven of allogrooming. No territorial behaviour was observed.

[17] Note that the numbers reported for Year 1 do not tally with those reported in our first annual report because that report covered a period slightly longer than the first year of the project.
[18] The increased number of identified observations in Year 2 is due to the increase in the number of beavers present (due to the release of two additional pairs towards the end of Year 1).
[19] Grooming of another beaver (always a family member).
[20] Two beavers face each other and touch noses. The behaviour usually occurs when two familiar beaver meet each other and probably allows individuals to identify each other.
[21] Two beaver (family members) face each other, press fore-paws against their opponent and rise up on their hind-quarters.



a) Year 1 (n (total observations) =522, 23 not classified)



b) Year 2 (n=1481, 67 not classified)

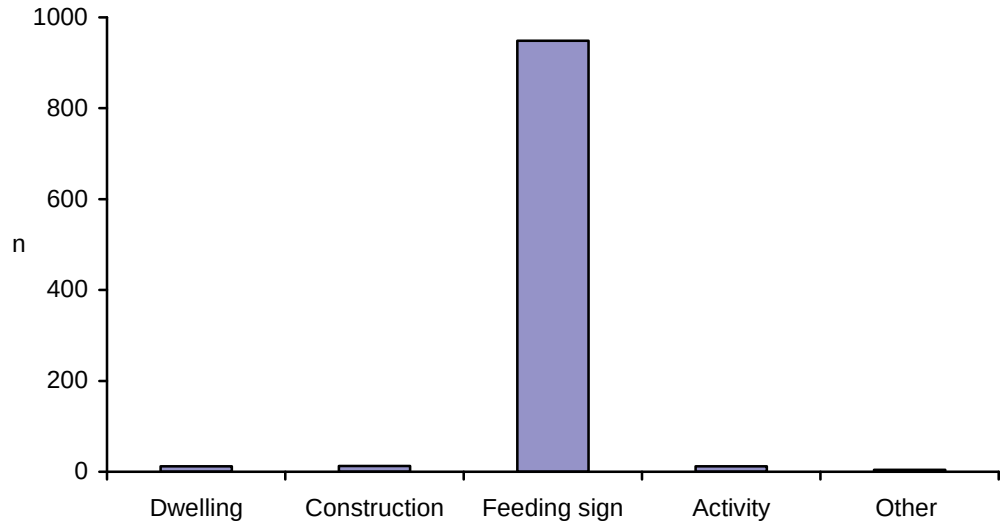
Figure 4. Activity types recorded during observations of beavers, in Year 1 and Year 2. Locomotion includes swimming, walking and diving. Foraging includes foraging on woody, herbaceous and aquatic vegetation. Territorial behaviour includes scent marking, fighting and stick displays. Social behaviour includes nose-to-nose interactions, wrestling, allogrooming and caravaning[22]. Miscellaneous behaviour includes building, grooming, sitting or lying still in the water, alert postures, provisioning (taking food to the lodge, usually for young kits), tail slapping and other unknown behaviours. A brief ethogram is given in Campbell et al. (2010).

[22] A young beaver latched onto the hind-quarters of an older animal as it swims. This usually only occurs with newly emerged beaver kits in July and August. This behaviour was not observed in Year 1 and 2 but has been seen recently with the new kits born in Year 3 (this will be reported on in the next annual report).

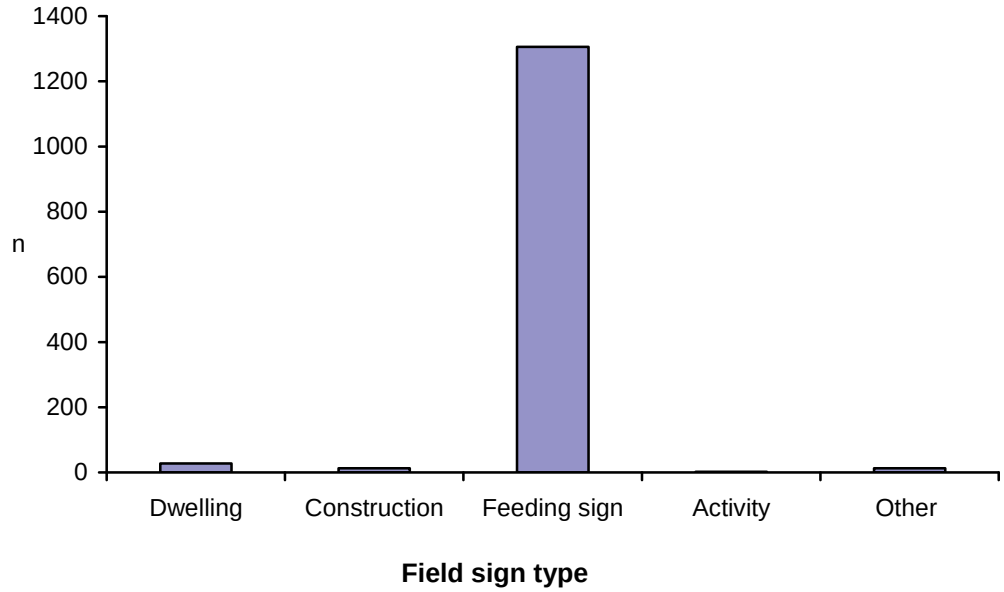
3.4.2 Field sign data

Over two years, a total of 2351 field signs were recorded (990 in Year 1, 1361 in Year 2). Again, the number of field sign locations were similar among families (Table 8, 3.4.3 below).

In both Year 1 and Year 2, most signs recorded were feeding signs (Figure 5); most of which were some type of cut branch or tree (including cut and felled trees, saplings or branches, gnawed trees, and stripped branches or sticks) (Figure 6). Other field signs recorded were dwellings (burrows and lodges, as well as improvements to existing lodges), construction (dams and canals), and tracks. There were nine records of scent mounds or scent marking in Year 1; but none in Year 2.

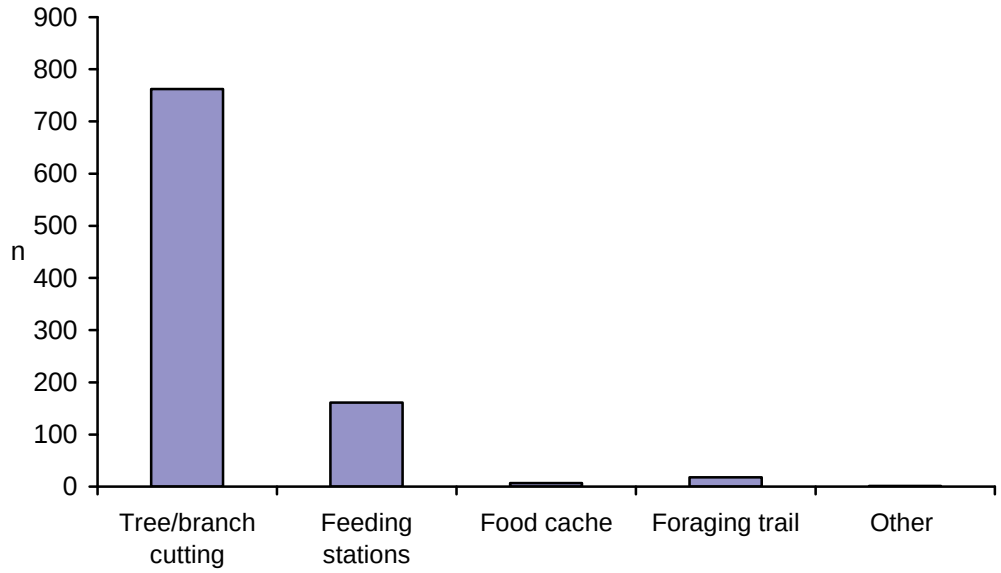


a) Year 1 (n (total field signs) = 990, 2 not classified)

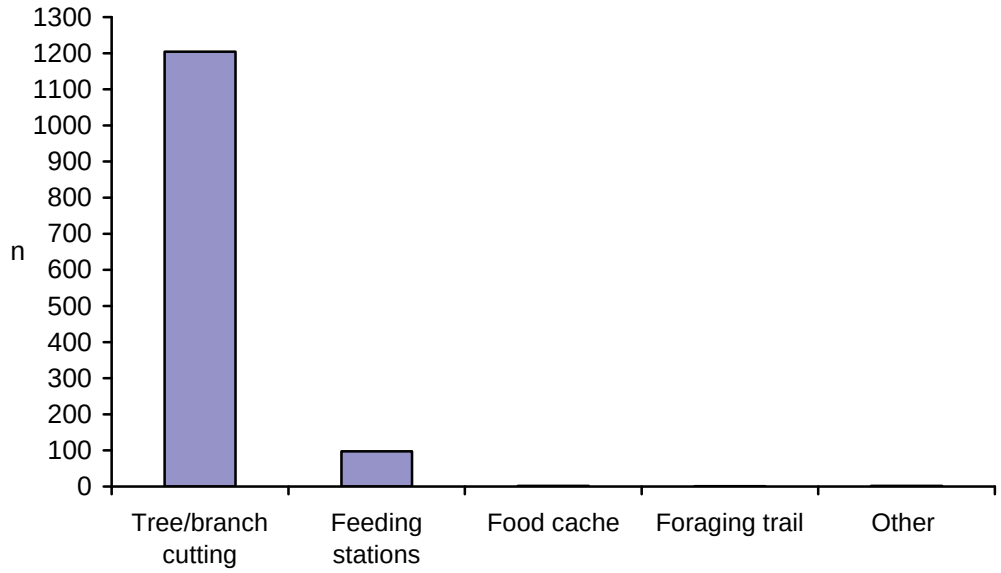


b) Year 2 (n=1361)

Figure 5. Types of beaver field signs recorded, in (a) Year 1 and (b) Year 2.



a) Year 1 (n (total feeding signs) = 949)



b) Year 2 (n=1306)

Fig 6. Types of beaver feeding signs recorded, in (a) Year 1 and (b) Year 2. Tree/ branch cutting includes felled trees or saplings, cut tree stumps, gnawed trees, cut branches and stripped branches or sticks. Food caches are underwater stores or cut saplings and branches outside the lodge/burrow. 'Other' includes grazed areas and aquatic macrophyte mats.

a) beaver lodge (Loch Linne)

b) beaver dam (Dubh Loch)

c) felled trees (Loch Linne)

d) beaver teeth marks

e) small feeding station at water's edge

f) aquatic plant debris

g) felled, large mature birch

h) gnawed tree (marked with wool)

i) cut spruce

j) cut hazel branches

k) bark stripping

l) grass cropping

g) beaver tracks

h) beaver burrow on the R. Add (see 3.5.2)

Fig 7. Beaver field signs recorded during the first two years of the trial, 2009-2011.

3.4.3 Home range/ Territory sizes

Two beaver families established territories in the first year of the project: Family 2 and Family 3 on Loch Linne and Coille-Bharr, respectively. Family 1 failed to establish. Family 4 and Family 5 were released towards the end of the first year of the project (see Table 1), both have now settled and established territories but are only in their first year post-release. Further, Family 4 currently consists of the female, released in May 2010, and a male released later in September 2010; in future analyses, it would be preferable to measure the home range of this pair since the time of the second male's (Christian's) release.

Territory sizes were calculated in Ranges 7 (www.anatrack.com). On the basis of preliminary analyses in Year 1 (Harrington *et al.* 2011), we considered 100% restricted edge polygons (REPs)[23] (using a restriction distance of 0.2) to provide the most appropriate estimate of territory area. For comparability with other studies of beavers, and in accordance with Herr and Rosell (2004), we also calculated 100% minimum convex polygons (MCPs), and measured the length of waterway edge within the polygon defined by the MCP to provide an estimate of the length of river/loch bank used over the year. Loch/river bank lengths were calculated in ArcGIS 10.0 (www.esri.com).

[23] Minimum convex polygons (MCPs) are the smallest polygon that can be drawn around a set of locations where the external angles are all greater than 180º. 100% MCPs include all locations within the polygon; they are a widely used technique and are therefore particularly useful for comparisons among studies. The area and shape of MCPs are heavily influenced by outlying locations and restricted edge polygons (or concave polygons) may provide a better method if MCPs include large areas that are not visited by the animal (e.g. a patch of unsuitable habitat). REPs are constructed by drawing lines between edge locations in the same way as for MCPs except that lines are only drawn if they are shorter than a selected fraction of the range width (the 'restriction distance'; 0.2 in this case), resulting in a concave range where linkages between edge locations are long. The restriction distance, in this analysis, was selected as the smallest distance that did not result in fragmentation of the range (as used by Harrington and Macdonald 2009).

Table 8. Yearly home range size estimates one and two years post-release for 4 beaver families/pairs, Knapdale, 2009-2011.

n=number, FS=field signs, obs ID= observations of identified animal, obs non-ID= observations of unidentified animal, REP=restricted edge polygon (see text), MCP=minimum convex polygon.

Family	Members	Release date/ birth date	1 year post-release n FS n obs ID n obs non-ID	2 year post-release n FS n obs ID n obs non-ID	100% REP (d=0.2) (ha)	100% MCP (ha)	Length of river / loch bank (km)
2	Frank	30/05/2009	484 FS 180 obs ID 86 obs non-ID **750 total**	512 FS 117 obs ID 288 obs non-ID **917 total**	Year 1 25.0	Year 1 27.8	3.5
	Frid						
	Biffa*				Year 2 24.7	Year 2 27.3	3.7
	KitLinne	2010					
3	Bjornar	30/05/2009	338 FS 140 obs ID 27 obs non-ID **505 total**	442 FS 173 obs ID 280 obs non-ID **895 total**	Year 1 45.4	Year 1 57.3	4.5
	Katrina						
	Mille				Year 2 41.9	Year 2 48.3	4.5
	Marlene*						
	KitDubh	2010					
4	Tallak	04/05/2010	275 FS 281 obs ID** 55 obs non-ID **611 total**	-	Year 1 14.0	Year 1 25.0	3.0
	Trude						
	Christian	21/09/2010			Year 2 -	Year 2 -	
5	Eoghann	23/06/2010	299 FS 215 obs ID 72 obs non-ID **586 total**	-	Year 1 7.8 ***	Year 1 9.5 ***	1.5
	Elaine				Year 2 -	Year 2 -	

*subadults missing presumed dispersed
** note that preliminary estimate includes locations for Tallak (no longer present at the site)
*** not yet one year post-release, but analysed as is for purpose of this report

Home range sizes were variable amongst families/pairs of beavers (Table 8) but seemed to reflect the area of the loch (i.e. the beavers appeared to use the area of riparian habitat that was available to them, see Fig. 8). Territory location and size showed no apparent change between one and two years post-release for those families that were in their second year (Table 8, Fig. 9). For all beaver families/pairs (perhaps with the exception of Family 5), winter home ranges appeared to be smaller than those used in other seasons (Table 9). However, the presence of outlying points (see Fig. 10) in winter suggest that perhaps the difference is in the intensity of use rather than the area used per se (and, in this case, REP's underestimate the actual area used per season).

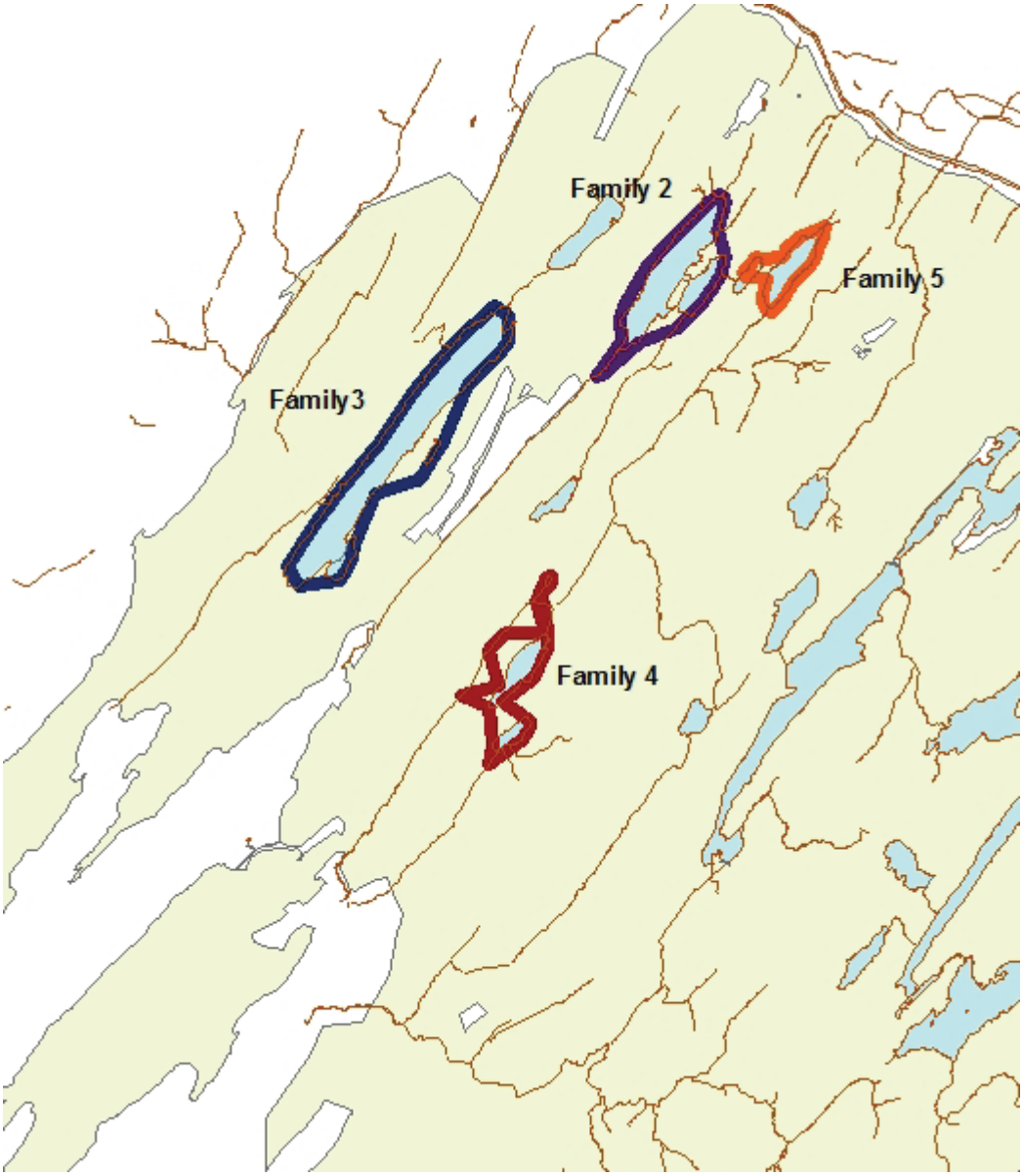


Fig 8. Yearly home ranges, June 2010- May 2011 (two years post-release for Family 2 and 3, one year post-release for Family 4 and 5), based on REP 0.2

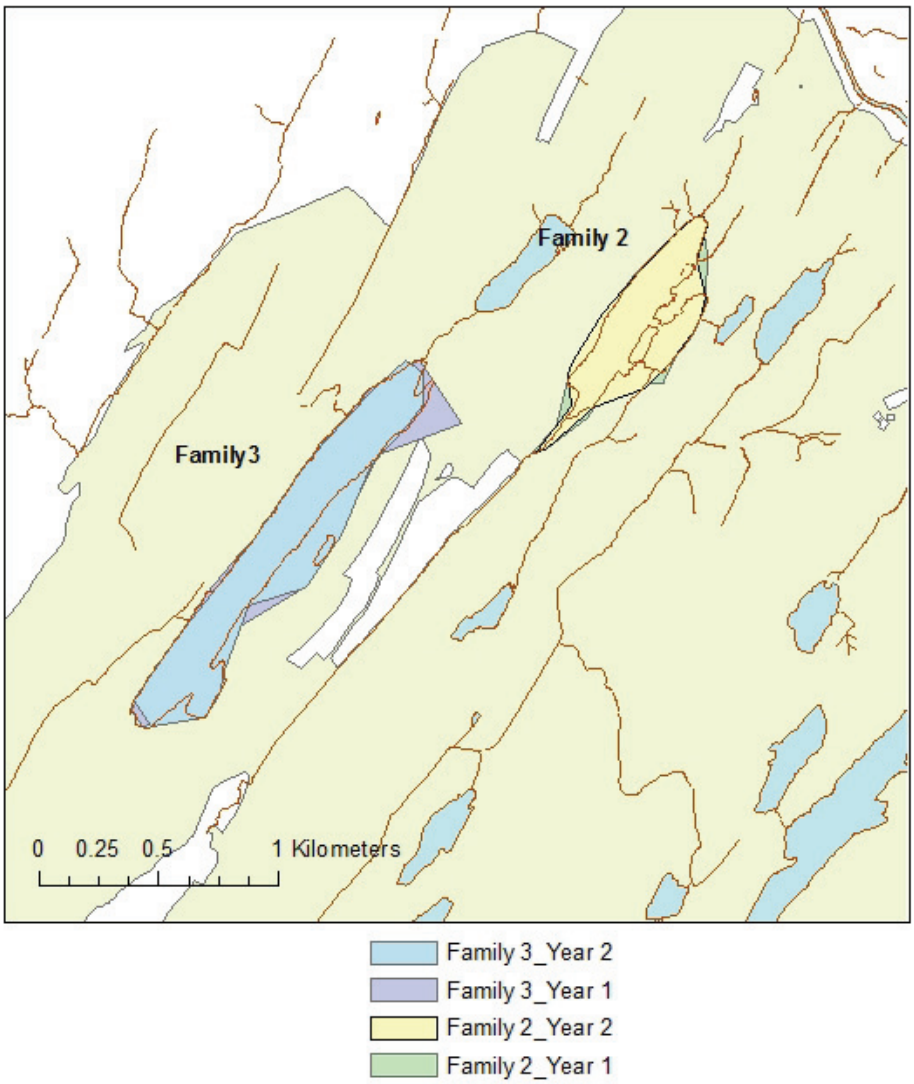
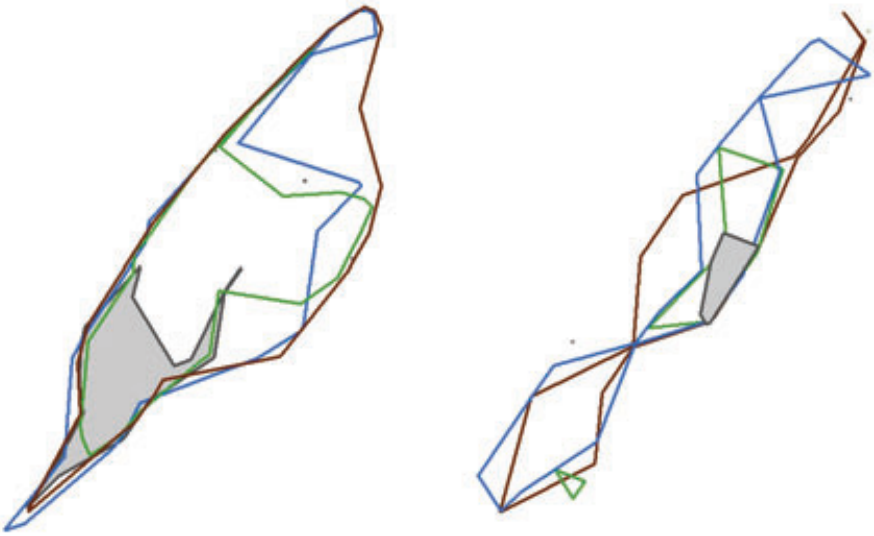


Fig 9. Yearly home ranges for Family 2 and 3 one and two years post-release. See Table 8.

Table 9. Seasonal home range sizes in 2010-2011 (two years post-release for family 2 and 3, one year post-release for Family 4 and 5), based on REP 0.2. Data are: home range size in ha, n(FS), n(obs). Note that field sign survey protocols were only seasonal in spring 2011 and therefore sample sizes were smaller than in previous seasons in 2010 when field sign surveys were monthly.

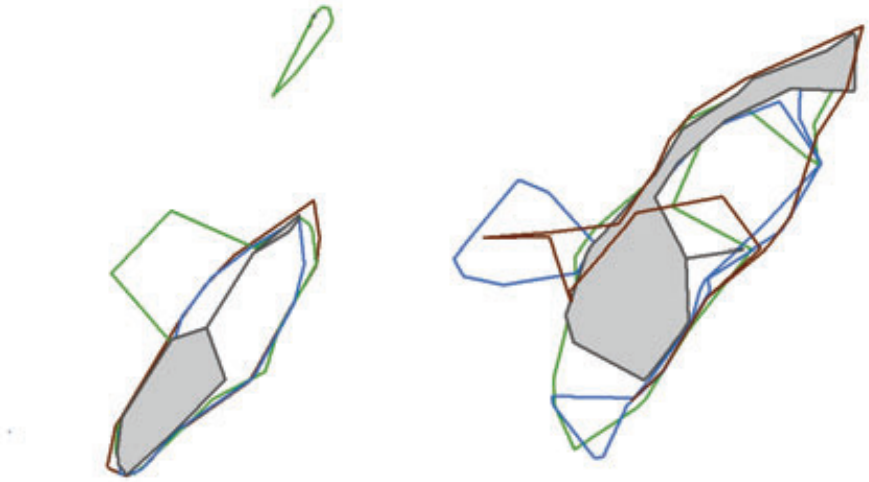
Family	Summer	Autumn	Winter	Spring
Family 2	17.5, 119, 215	22.8, 279, 125	4.4, 84, 25	13.0, 30, 40
Family 3	24.7, 58, 231	23.7, 242, 100	2.2, 96, 65	7.7*, 46, 57
Family 4	5.7, 98, 34	5.0, 101, 173	1.8, 41, 27	6.8*, 35, 66
Family 5	1.9*, 84, 72	3.0, 117, 116	2.5, 52, 38	4.1, 37, 28

* Home range sizes are underestimated because they fragment into two or more separate areas of use



a) Family 2

b) Family 3



c) Family 4

d) Family 5

Fig 10. Diagrammatic representation of seasonal home ranges for Year 2, for all beaver families/pairs (not to scale). Home range estimates are REP's with a restriction distance of 0.2. See Table 8. Family 2 and 3 were in their second year post-release, Families 4 and 5 in their first year post-release. Summer = blue, autumn = brown, winter = grey (shaded), spring = green. Note outlying winter locations showing that the actual area used in winter is larger than that estimated by REP's.

3.5 Movements and dispersal

3.5.1 Post-release movements within the trial area

Distances from the release point to the centre of the yearly group territories at one year post-release were approximately 0.4, 0.8, 0.25, and 0.1 km for Families 2, 3, 4 and 5, respectively (in all cases the release sites were contained within the estimated home range) (Figure 11).

In the absence of radio-telemetry data it was not possible to estimate nightly movement distances. Estimates of nightly movements will be provided by GPS telemetry in future years (see Appendix A).

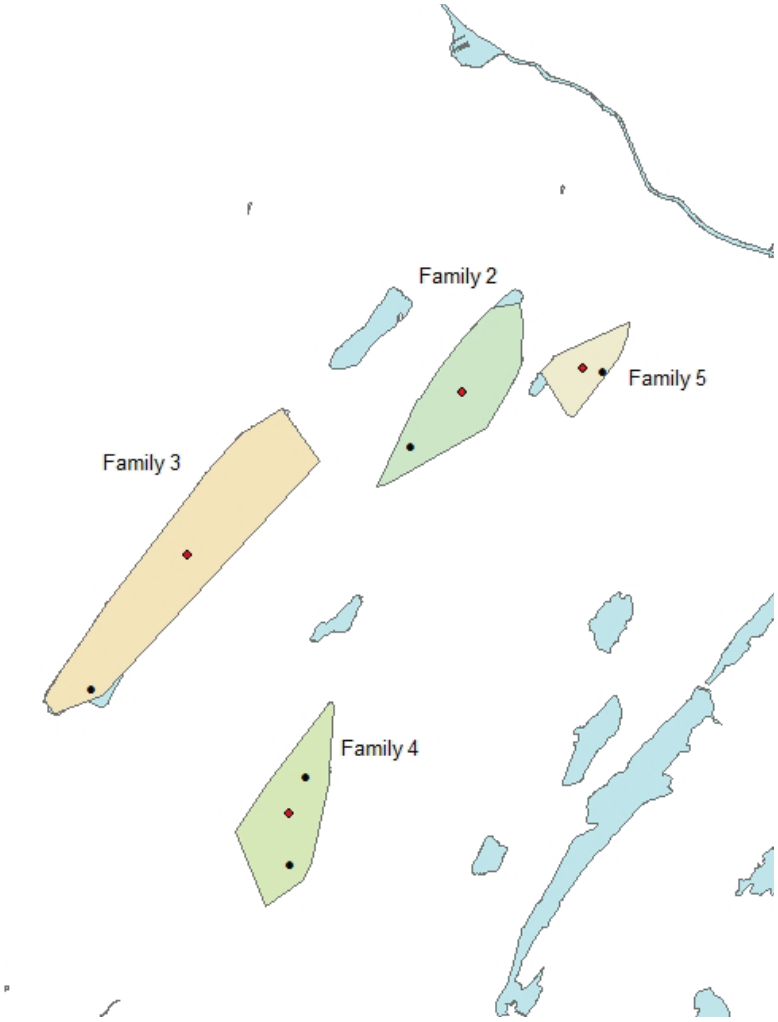


Figure 11. Yearly territories (estimated using 100% MCPs, shown as polygons, red dots are mean centres), one year post-release, and respective release sites (black dots). Note that one-year post-release for Family 2 and 3 was in Year 1 of the project, and for Family 4 and 5 in Year 2 of the project. Blue areas are waterbodies.

3.5.2 Post-release movements <u>outwith</u> the trial area

Three individuals are known to have moved outwith the release area: Andreas Bjorn, Gunn Rita and their female kit (Mary Lou). Andreas Bjorn left the release area within a few weeks of release and was located approximately 10 km north of the release area at Kilmartin Fish Farm in August 2009 (where he was recaptured and returned to the release site, although later removed from the programme, see footnote 11). Gunn Rita disappeared in the second week post release, her female kit disappeared in mid-July 2009[24]. The kit was initially tracked via VHF telemetry to the Crinan Canal but then disappeared. Beaver activity was noted on the River Add, approximately 3 km north of the trial area in October 2009 (Figure 12), but previously-occupied burrows appeared to have been abandoned following flooding of the river in early winter 2009 – although further field signs were recorded at the same location in March 2010, none were reported to be fresh. A small beaver (of unknown identity) was sighted (and old field signs recorded) on Crinan Canal in April 2010 less than a kilometre from the release area. It is not currently known whether these field signs and observations are of Gunn Rita, her young kit (Mary Lou) or both.

Two other beavers are believed to have left the release area – both were sub-adults that dispersed from their natal group (see below, 3.5.3).

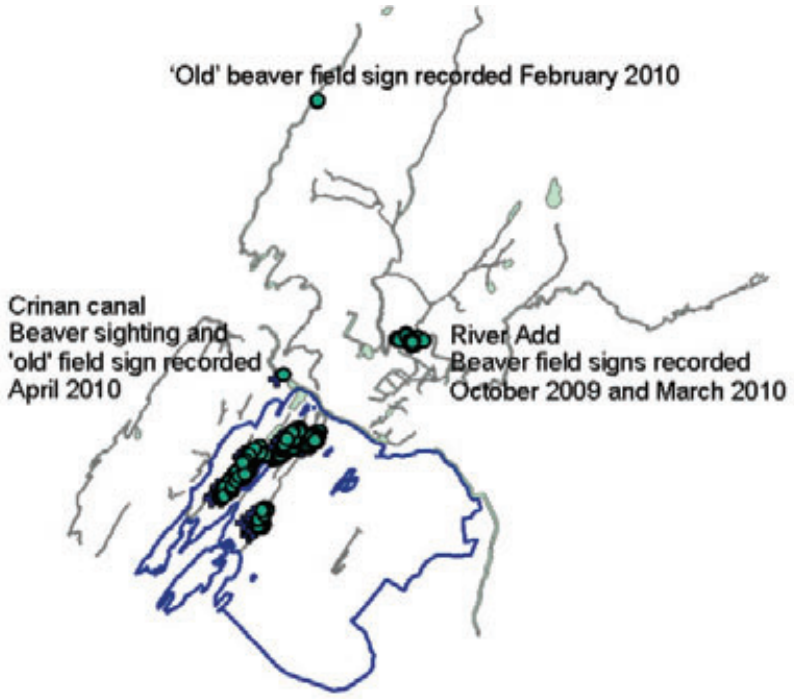


Figure 12. Field signs and observations (green dots) of beavers recorded outside the release area during Year 1 of the trial, 2009-2010. The blue line shows the boundary of the Knapdale release area.

[24] In the interim period, in the absence of her mother, Mary Lou had been provided with supplemental food

3.5.3 Dispersal by sub-adults

In the first two years of the project, two dispersal events of a subadult away from the natal group were recorded. One was dispersal of a two year old female in Family 3 (Marlene), and the other a two year old male in Family 2 (Biffa).

Marlene was observed fighting with another family member in June 2009 (in the first month post release). She was tracked via VHF telemetry south-west to a watercourse in the vicinity of the Fairy Isles and then to a nearby sea loch in August 2009. She has not been seen since.

Biffa remained with Family 2 for almost two years (1 year, 10 months) post-release. He was last seen in February of 2011.

3.6 Habitat Use: deciduous woodland preference

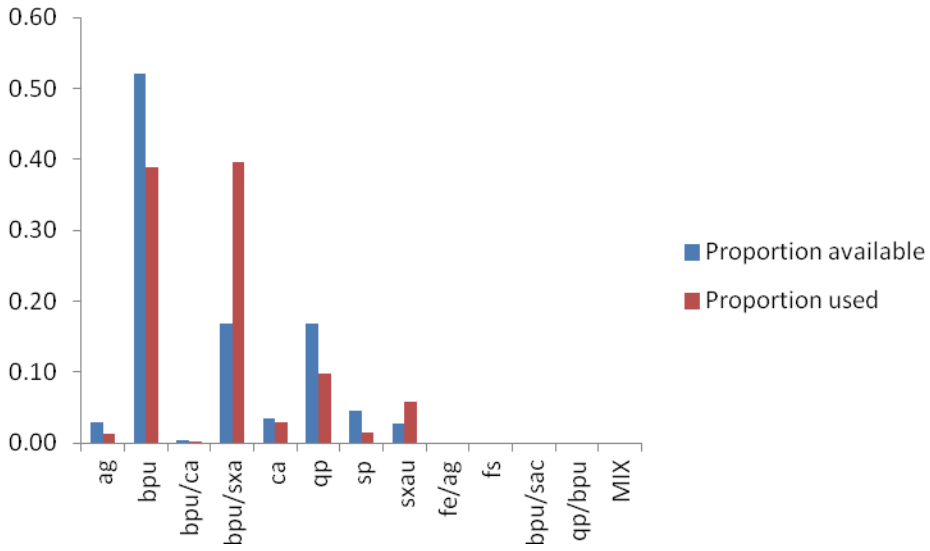
In all cases, beavers settled either at their release site or on the neighbouring loch – there was no evidence of early exploration of a wider area, and therefore, no suggestion that the beavers chose their territory location beyond simply settling where they were released, or close by (within 1 km of their release site, Fig. 11). Further, all families used the entire perimeter of the loch at which they were released and settled. Investigation of group territory location choice was therefore not relevant. It is possible that further movements will occur in future years, and if this is the case, broader scale analyses of habitat selection may be appropriate.

Analysis of habitat use for this report was thus limited to habitat use within the beavers home range (level II analysis), and was carried out at the level of the beaver family/pair. In this preliminary analysis, we focused specifically on use of deciduous woodland types (as defined by the dominant species present). Habitat use, more generally, as well as among years and seasons, will be investigated more fully in later reports.

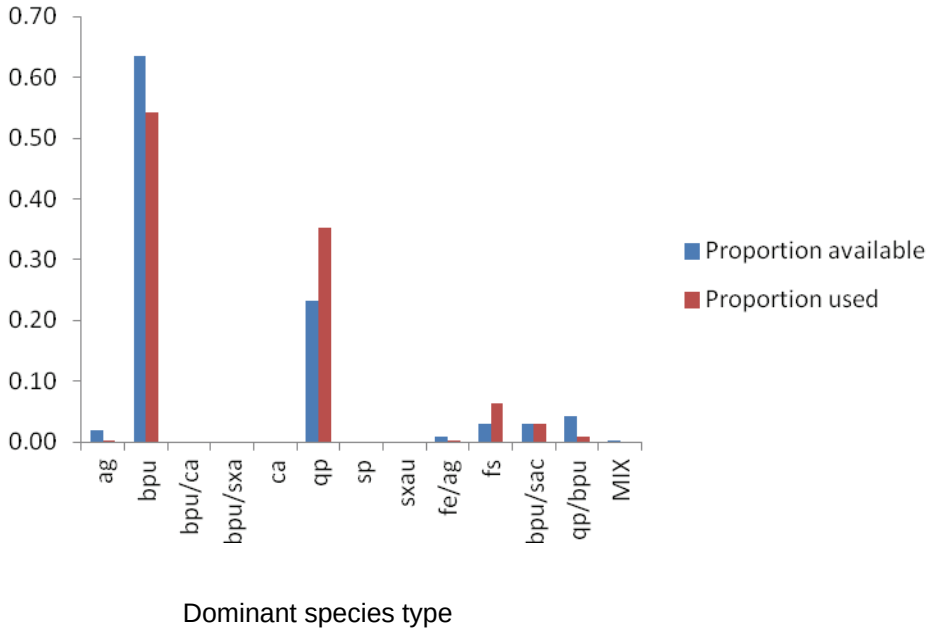
We used the Knapdale woodland deciduous 2005 dataset (Brandon-Jones *et al.* 2005)[25] to assess habitat availability. Field sign locations[26] were used to quantify habitat use. Proportions of locations within each woodland type, and proportions of each woodland type within the home range (based on the minimum convex polygon + a 10 m buffer) were estimated in ArcGIS 10.0 (www.esri.com).

[25] Updated in 2011

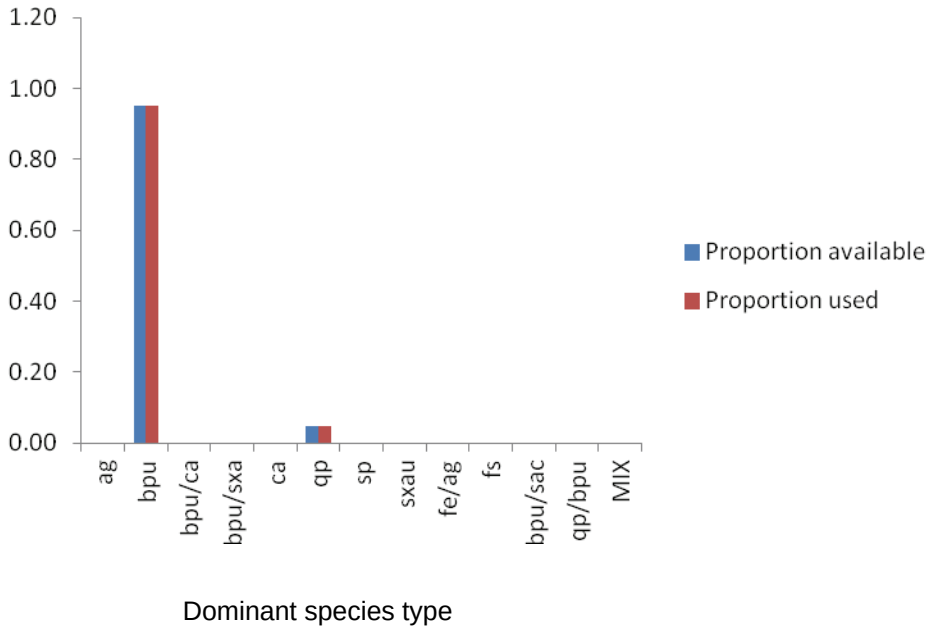
[26] All types of field signs (feeding signs as well as locations of lodges and dams) were included in this analysis; future analyses will consider different beaver activities (e.g. feeding, shelter, travel) separately.



a) Family 2



b) Family 3



c) Family 5

Figure 13. Proportional composition of deciduous woodland (by dominant species) within family home ranges, and proportional use by beavers (as revealed by field sign locations). Family 4 is not shown because only one dominant species type – downy birch, Betula pubescens – was present within their home range. Codes are as follows: ag= Alnus glutinosa (common alder), bpu = B. pubescens (downy birch), bpu/ca = B. pubescens/ Corylus avellana (downy birch/ common hazel), bpu/sxa = B. pubescens/ Salix aurita (downy birch/ eared willow), ca = C. avellana (common hazel), qp = Quercus petraea (sessile oak), sp = Pinus sylvestris (Scots pine), sxau = S. aurita (eared willow), fe/ag = Fraxinus excelsior/ A. glutinosa (European ash/ common alder), fs = Fagus sylvatica (European beech), bpu/sac = B. pubescens/ Sorbus aucuparia downy birch/ rowan), qp/bpu = Q. petraea/ B. pubescens (sessile oak/ downy birch), MIX = mixed.

The most dominant deciduous tree species within all beaver home ranges was downy birch; all beaver families appeared to use woodland dominated by this species in proportion with (or slightly less than) than its availability. There was some evidence that Family 2 preferred (insofar as proportional use was greater than proportional availability) woodland dominated by downy birch and eared willow, and avoided (proportional use less than proportional availability) sessile oak; Family 3, however, in contrast appeared to show some preference for areas dominated by sessile oak. Family 5 occupied a less diverse deciduous woodland and appeared to use it in proportion to its availability.

These preliminary findings are broadly in accordance with the more detailed analyses of the effect of beavers on riparian woodland carried out by the James Hutton Institute (JHI). They report that downy birch is the most dominant tree species on most of their monitoring plots, and they suggest that beavers prefer willow (and rowan), and that although birch is the species used most commonly by beavers, it is used in proportion with its abundance (see Moore *et al.* 2011 for further details). They also found that beavers appear to avoid alder and hazel. Sessile oak was poorly represented in the JHI monitoring plots and therefore categorised as 'other' species, with a number of low abundance species; however, they note in their report that

although sessile oak is common and widespread at Knapdale, within 30 m of the water it tends to be found in areas unsuitable for beavers (steep and rocky), which would explain our findings of avoidance of areas dominated by sessile oak by Family 2, but not the apparent slight preference shown by Family 3.

The JHI woodland monitoring differs from the assessment of habitat use by beavers included here in the ecological monitoring of the beavers themselves in both the scale of the monitoring and the detail. The JHI monitoring is based on detailed monitoring of 31 transects comprising 111 (4x10 m) permanent vegetation plots between zero and 30 m from the water's edge distributed across the five lochs used by beavers at Knapdale. Whereas assessment of habitat use by beavers reported here is carried out at the level of the beaver family within their entire home range but in considerably less detail. To reduce overlap and redundancy in the monitoring work, the beaver ecology monitoring no longer collects data on the size, number (or proportion), or the species of felled trees (see 2.4). Here, we refer only to the location of field signs and the broad habitat types within which they are found. Further comparisons between the two separate monitoring exercises will likely be informative and will be covered in future reports.

3.7 GPS Telemetry

Preliminary trials and accuracy testing suggest that both inter-fix intervals (most, >90%, successive fixes were achieved within 30 minutes or less) and accuracy of locations obtained (median errors 5-19 m, maximum errors 23-75 m) are adequate for the purpose of the ecological monitoring of beavers at Knapdale.

Fixes were not obtained from inside the lodge, but this will actually be beneficial because it will be useful for assessing activity periods and emergence times. Trial deployments on two animals show that beavers appear not to use their entire HR in 8-9 days (the deployment duration), therefore GPS data will be most useful for assessing nightly movements and intensity of use of the home range (over short periods). Estimation of nightly movements in particular are required data for the ecological monitoring (see Campbell *et al.* 2010) but are not currently possible with existing monitoring methods. Relative imprecision may, however, impose limitations on finer-scale analyses e.g. habitat use.

Further details of trial deployments of i_Got_U tags, and accuracy assessments of the method, will be provided in the third annual report.

3.8 Other riparian mammals

Data on otter and mink presence at all 20 survey sites in Year 1 and Year 2 were provided by SNH. Additional data on mink presence were available from 10 mink rafts installed by SBT for mink-control purposes. Weather conditions and delays in the timing of the survey in both Year 1 and Year 2 meant that otter (and mink) presence may have been underestimated (see Appendix B). It is likely that the nature of the survey sites and the timing of the survey are not suitable for providing supplementary data on water vole presence within the release area (however, this was not the main aim of the survey).

Evidence of otter activity (mostly spraints or footprints/otter paths) was recorded at eight sites (80%) in each of the trial area and the control area in Year 1, and in seven sites (70%) in each in Year 2 (details in Appendix B). This is slightly lower than the overall mean number of positive sites recorded across the SNH Argyll & Stirling Area during the 2003/04 national survey (89.13%). It is possible that both year's survey results were underestimated due to the high water levels and leaf-fall in the days

prior to the survey and high snowfall towards the end of the survey. However, interestingly, in Year 2, the quantity of spraint found at some of the positive survey sites within the release area was substantially greater than at any of the positive sites in the control area (perhaps suggesting a higher level of overall otter activity within the release area).

In Year 1, mink signs were recorded at one of the survey sites in the control area, and a further three sites had 'possible' mink presence (one in the release area and two in the control area, see Appendix B). In Year 2, mink were confirmed at one site, and possibly present at one other (both in the control area). Ten mink rafts are monitored by SBT at monthly intervals: mink tracks were found on two occasions in Year 1 and on 10 occasions in Year 2. Two mink were shot as part of control operations for this non-native species in Year 2.

No evidence of water voles was found, but this is not surprising given the late autumn/winter survey dates and the heavily-shaded habitat at many of the locations. No other signs of water vole have been recorded at Knapdale before or during the trial.

4 DISCUSSION - APPRAISAL OF METHODOLOGY

Throughout the five year trial, we will continually assess the suitability of the monitoring methods (both field and analytical methods), to ensure that sample sizes (e.g. the number of beaver locations recorded) are adequate for the analyses carried out, and to improve our methods where possible. However, it will also be crucial to maintain some level of consistency to ensure comparative longitudinal data for the duration of the project. Field signs are relatively straightforward to record, and appear to provide a fairly comprehensive picture of the terrestrial areas used by the beavers, and of their activities on land – field sign surveys will, thus, be continued throughout the project, albeit at a reduced frequency, but over a larger area. Observational locations, on the other hand, added little to field sign surveys, and, given the efforts required to carry out observational surveys, the decision has been made to discontinue these as an essential monitoring method. To compensate for the loss of observational locations, and to provide additional required information (such as nightly movement distances) we proposed the use of two new methods: GPS telemetry and depth-temperature recorders

4.1 Sample sizes

Previous studies of beavers in Telemark, where animals were located every 15 minutes, found that the minimum number of locations required to calculate meaningful estimates of home range and habitat use was about 90 over approximately three nights (Campbell *et al.* 2005; Schlichter (2008) cited in Campbell *et al.* (2010)). Incremental plots of Year 1 territory size against the number of beaver locations (see Harrington *et al.* 2011) showed that estimates of both yearly and seasonal territory size had stabilised (i.e. the number of locations was sufficient to calculate territory size) for both Families 2 and 3, and that approximately 100 locations were required.

A reduction in the frequency of field sign surveys in Year 2 (seasonal as opposed to monthly), and the loss of additional observational locations, mean that sample sizes for home range estimation are now reduced. For yearly home ranges, however, sample size, even for field signs alone, remains well over 100 (see Table 8). Estimation of seasonal home range size is a little more problematic as, in some cases, sample sizes were as low as 25. Nevertheless, home range size estimates, even for seasonal home ranges, showed stabilisation, suggesting that sample sizes remained adequate. However, the presence of outlying locations, and the occurrence of fragmentation when using restricted edge polygons (REP's), suggests that REP's might be inappropriate when sample sizes are small. In future, we will use MCP's and the length of waterbank within them, as a more suitable method for the estimation of seasonal home range size.

4.2 Use of GPS – advantages

Traditional, commercially-produced, GPS transmitters had been deemed prohibitively expensive in the early stages of the beaver release. However, the discontinuation of VHF telemetry in the first year of the project meant that there were gaps in the data. Although, observations and field signs are able to provide useful data on beaver locations, both are subject to a number of biases (see Harrington *et al.* 2011) and the two datasets are not easily combined for statistical analysis. The i-Got-U GPS tags that are currently being trialled (see 2.5, and Appendix A) are unlikely to be precise enough to allow fine-scale analysis of habitat use, and the short (approximately 8 day) deployments that are possible with these tags may not be sufficient to provide alternative estimates of home range size. However, they have two advantages: 1. they provide detailed information on nightly movements, and 2. they provide

information on the movements of specific individuals. 1. is required information, that we were formerly unable to provide, and 2. is important to verify the distinct family home ranges, and lack of inter-family/pair overlap, suggested by plots of field sign locations. 2. is likely to become increasingly important over time, and particularly as beaver density increases.

4.3 Use of depth-temperature recorders (DTRs) – advantages

One unanswered question that still remains even if GPS tags are used, is to what extent beavers use the aquatic habitat. The resolution of GPS locations mean that it will not be possible to distinguish between a beaver on the land at the edge of the bank and a beaver in the water at the edge of the loch. Detecting aquatic habitat use from GPS data is also complicated by the fact that a fix will only be obtained if a beaver in the water is at the surface, but not all 'surfacing events' will be recorded due to the 15 minute fix interval. Field signs are not usually detected in the water, although macrophyte 'mats' are sometimes observed. Although beavers are observed foraging in the water, observational data are the most labour intensive of all monitoring methods and obtaining long duration data on focal animals is difficult and subject to bias due to observers disturbing the animal.

DTRs record depth and temperature at second intervals (for approximately 6 days), and provide very detailed dive profiles. Whilst it may not be possible to distinguish between foraging dives and travelling dives, or dives approaching the entrance to the lodge, dive data will provide information on the amount of time spent in the water, which, coupled with known activity periods from the GPS data, will allow us to infer the proportion of 'active time' that beavers spend in the water. DTRs will, thus, provide a useful additional source of 'essential' monitoring data allowing us to better understand beaver ecology and behaviour at Knapdale. Additionally, DTRs will provide unique, 'non-essential' data on beaver diving behaviour.

DTRs will be deployed on a sample of animals in spring 2012. For further details see Appendix A.

5 DISCUSSION – BEAVER ECOLOGY

At the end of the second year of the trial, reported here, both mortality and animal loss remain relatively low (three of 16 animals released died, and four or 16 released animals have been lost). It is too early in the trial to make any attempt to assess trends but it is perhaps noteworthy that there have been no mortalities in the second year of the project (and indeed, all mortalities occurred shortly after the individual animals were released, following a period of captivity and transport that is undoubtedly a stressful, but necessary, part of any translocation exercise). Further, all animals that have been captured appear to be in good body condition. In the second year of the project there was only one loss (compared with three in the first year of the project). Regarding animal 'losses', however, it is possible that these will increase as more of the released animals, and their offspring, reach dispersal age.

Although the number of kits produced per family (only one in all cases thus far) is low, the proportion of females breeding (both of two in Year 1 and potentially three[27] in Year 2) appears to be relatively high compared with what is known of wild beavers (amongst wild Eurasian beavers, only 50-60% adult females usually reproduce, Müller-Schwarze and Sun 2003).

Territory sizes reported here are in line with territory sizes reported for beavers by Herr and Rosell (2004) and lie within the range of territory sizes (0.5–12.8 km) reviewed by Macdonald *et al.* (1995).

In future reports, survival and reproductive rates (and potential for population growth), as well as home range size and habitat use, will be compared with other European releases of beavers, as well as data from wild populations of Eurasian beavers.

[27] At the time of writing this report, it was not known whether or not all three females suspected of being pregnant had successfully reproduced (and the fourth female had not been captured, so it was not known whether or not she was pregnant).

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APPENDIX A: REVISED METHODOLOGY PROTOCOLS AND WORK PLAN FOR YEAR 3

These procotols follow the general format as used in the original methodology protocols in Campbell *et al.* (2010), with a brief overview of each method as it applies to the trial, an outline of the workplan and the data required, as well as a summary of the key information provided by each method. These are revised protocols following amendments made during Year 1 (see Harrington *et al.* 2011) and following discussions between SNH, WildCRU and SBT in July/August 2010 and in January 2011. To provide a complete workplan for Year 3, we also include here the new GPS protocols as agreed with SBT in September 2011 (although timing means that this aspect of the workplan will not be implemented until half way through Year 3 of the project).

Trapping

Overview

The preferred technique is the Norwegian method of trapping from a boat because it allows targeted captures, and reduces individual recaptures and overall capture time. Trapping from a boat will, therefore, be used on all lochs where it is possible (current areas include Loch Linne, Loch Buic, Loch Collie-Bharr and Creagmhor). However, on some of the smaller lochs use of a boat is not feasible and, therefore, cage traps will be used at those sites (e.g. Dubh Loch, and Un-named Loch (North) [28]). Animal welfare is paramount in terms of suitable trapping method and duration of trapping effort, and thus, cage trapping at a specific location will cease if an individual is recaptured three times within a one-month period. Trapping should resume in an attempt to capture animals not yet trapped after a period of not less than two weeks, but not more than two months. All animals should be uniquely marked with both PIT tags and ear tags (using a variety of tags depending on circumstances). Argos tags, which the SBT initially used specifically for beaver management purposes rather than the ecological monitoring will no longer be fitted. VHF telemetry is not currently part of the revised methodology but may be used for management purposes.[29]

Over the first year of the project the most important outcome of the trapping data was the health and survival of individual released animals. In future years, identification of wild-born young will also be needed to allow assessment of their survival and description of population dynamics. Therefore, it should be a high priority to capture and mark any new, unmarked young animals. Every known animal should be trapped once per year. Trapping of new wild-born kits should be an additional priority. The weight of all animals captured should be recorded as well as standard body metrics (body length, tail length, width and thickness).

Work plan

The precise timing of the annual trapping is not critical and can be fitted in with other activities (but must be recorded so that methodology can be accurately reported). However, the earlier in the monitoring year trapping is carried out the more time is available for capturing animals not yet caught. Further, to allow assessment of annual variation in body condition (estimated from animal weight and body metrics), the timing of trapping should be relatively consistent over consecutive years of the project (i.e. within the same season). Late February to late spring when females may be pregnant

[28] A small lochan between Loch Fidhle and Creaghmhor, used by Family 5 (Elaine and Eoghann). Also known as Lochan Beag.

[29] ARGOS telemetry is not part of the ecological methodology protocols; VHF telemetry is not currently part of the revised methodology but may be used on 'new' animals and subadults likely to disperse for management purposes – data should still be provided to SNH and WildCRU so that its use (and potential relevance to ecological monitoring) can be further reviewed at a late date; new protocols for GPS telemetry are detailed below.

should be avoided for intensive trapping efforts with Bavarian cage traps. Trapping for kits should, ideally, be carried out as close to emergence time as possible so that early losses (mortality rates of kits in the first few months post-emergence) can be estimated. In the event that kits lose their ear tags, they should be recaptured, and new eartags fitted, as soon as possible.

Data — Data detailing the number of traps used and number of hours the traps are open (to allow calculation of trap effort) to be entered into the existing trapping spreadsheet[30]; trap locations of captured animals also to be recorded.

Key information provided

Survival of known individuals (yearly)
Body metrics for assessment of overall body condition
Reproductive rates (number of females breeding and number of kits per breeding female)
Population size and density within the release site
Age structure of the population
Dispersal (number or proportion of animals dispersing)[31]

Observations (visual checks)

Overview — Observational data offer a non-invasive alternative to repeat trapping of animals and observations can thus be considered as 'recaptures' in a capture-mark-recapture (resight) analysis (to determine survival and population size). Observation locations of the beaver can be used instead of radio-telemetry 'fixes' to determine territory sizes and, potentially, habitat use. It may also be possible to carry out detailed behavioural observations of focal animals[32]. The use of observations to assess survival and/or population size is dependent on the ability to identify individuals. Locations of unidentified beavers can, however, be analysed at a family level to assess family territory (home range) sizes and/or habitat use. The use of observational locations in analyses of home range size or habitat use are potentially subject to bias because animals are most often observed on the water and cannot be seen through the thick vegetation when they are ashore; biases can, however, be overcome to some extent by combining observational locations with field-sign locations (below). However, these methods are hugely resource-intensive and, therefore, given the biases inherent in these data and the fact that field

[30] trap effort = total trap effort = number of traps x hours that the traps are open

[31] Whether dispersal is 'natural' dispersal of young sub-adults leaving the parental group , or 'dispersal from the release site' by newly-released adults, the proportion of animals dispersing can only realistically be estimated from the disappearance (lack of captures and observations) of animals from the site. Further, in the event of a disappearance, it will not always be possible to determine whether the disappearance was due to dispersal or to mortality. Some information on minimum distances moved will be obtained from reports of field signs outside the release area

[32] Behavioural observations of focal animals are not currently included in the monitoring protocols but detailed behavioural studies of established beavers may be introduced in later years. Observations of beavers in Knapdale were, during the early phases of the release, somewhat problematic because newly-released beavers appeared to be disturbed by the presence of observers and/or the lights used by observers. Further, the behaviour of newly-released beavers is likely to differ in unknown ways from 'normal' behaviour of established animals. However, as beavers become habituated to observers and lights, and settle in the release area, focal observations should become possible, as well as more representative of 'normal' behaviour. Detailed behavioural data are supplementary to the essential ecological data currently being collected, but would be extremely valuable in further understanding the ecology of reintroduced beavers and may help to explain the ecological results obtained. The need for, and the feasibility of, focal behavioural observations will become apparent as the project progresses and will be reviewed and the practicalities discussed with SBT at a later date.

signs appear to be adequate to describe home range outlines (and that additional information on animal movements will now be provided by GPS – see below), we have decided that observational locations are no longer necessary for essential monitoring (as suggested in last year's report – see Harrington *et al.* 2011). Monthly observations of identified individuals remain important for estimates of survival, family group size and composition, dispersal of sub-adults and population size. Observations of lodges/dens to assess the number of wild-born kits are described separately below.

Spotlights should be used for observations in the dark if animals have been habituated; SBT have been habituating beavers to spotlights and should continue this with new wild-born animals.

Workplan — Observation sessions should be carried out monthly as part of the monthly visual checks carried out by SBT for management purposes. **Revised protocols require only one record of each animal per month.** Locations of all animals observed should be recorded, and, if an unidentified animal is seen, animal sex and/or approximate age class (i.e. adult or young) should be recorded.

Data — Observational records should be entered into the existing observation trial database.

Key information provided[33]

Survival of known individuals (monthly)[34]
Population size and density within the release site
Family size and composition
Sociality of the population[35]
Dispersal (number or proportion of dispersing animals) (see footnote 5 above)
Territory locations[36]

Lodge/den counts

Overview — Observing and counting individual animals as they emerge from the lodge or den in the evening provides additional estimates of family group size (Rosell *et al.* 2006), and, most importantly, if carried out during the period when kits emerge from the den, can provide information on the presence of kits, and estimates of the number of kits. During these observation periods it is sufficient to count the number and age-class (adults, yearlings and new kits) of all animals seen as they emerge from, and return to, the lodge or den. Observation periods should be as long as possible initially to maximise the likelihood of seeing animals as they first emerge from the den in the evening – the timing of observation periods can then be refined (and potentially shortened) in future years, as necessary. A number of repeat observations of each lodge/den should be made to increase the likelihood of observing all animals present (Rosell *et al.* 2006).

Observations of lodges or dens could potentially be carried out either by observers directly or indirectly using remote video. Currently, direct

[33] Information on beaver behaviour will also be provided if focal observations are carried out in future years.
[34] Dependent on identification of the animal
[35] Dependent on observations of two or more animals together or of observations of multiple animals leaving the same lodge/den
[36] Recorded locations of identified individuals will provide verification that known beavers are present within home ranges mapped on the basis of field sign distribution.

observations by one or two observers are considered most reliable, and this is the method that will be used at Knapdale. The potential usefulness of remote infra-red video cameras at lodges/dens (as either a replacement or supplementary method) may be investigated if time and resources allow.

Workplan — Fortnightly evening observations (from 8-12 pm) of all active lodges or dens, where the presence of pregnant females is suspected, should be carried out when kits emerge (from mid-July to the end of September[37]).

Data — Counts of animals at lodges/dens should be entered into a separate spreadsheet with columns for lodge/den location (name of loch and grid references), date, numbers of observed adults, 2-year olds, yearlings and kits, so that there is a row for each evening observation for each lodge/den.

Key Information Provided

Reproductive rates (number of breeding females and number of kits per breeding female)

Field sign surveys

Overview — A lot of useful information can be gained from field-sign surveys. These surveys can be used to locate dams, lodges and dens, territory borders and areas of high foraging activity. Assessment of habitat use based only on field signs is biased towards use of woody vegetation (there are few obvious signs of foraging on herbaceous or aquatic vegetation), but field signs can be supplemented by other more difficult and/or labour intensive methods (e.g. direct observations, telemetry or other types of dataloggers – see below) to provide a more complete picture of beaver foraging-habitat use.

Field signs (and their locations) should be recorded during foot or boat surveys along loch and river banks. Surveyors should walk (or travel by boat) until a field sign is observed. If it is a single field sign, record its location (and other associated data). If it is a patch of the same type of field signs, record the location in roughly the centre of the patch (and record any other information for that patch as a whole)[38]. If there are more than one type of field sign record both with the same location. For activity and foraging signs only one location (for either a single field sign or a patch of field signs) per 10 m length of bank needs to be recorded[39]. Field signs that should be recorded include: dwellings (lodges and burrows), construction (dams and canals), feeding signs (food caches, tree/branch cutting, feeding stations, foraging trails and grazed areas), and signs of other activities (tracks, droppings, scent mound or marking) (see Methods: Table 3). For feeding signs, only fresh signs (i.e. those left within the last 3 months) should be recorded; for other field signs (e.g. lodges, burrows, or scent mounds), only those with evidence of recent (within the last 3 months) use should be recorded. Dams can be recorded repeatedly although additional notes on recent maintenance activity and/or deterioration should be recorded in the database, and photographs

[37] One kit was first seen emerging from the den in mid-September (in 2011 – preliminary Year 3 data), which was later than originally expected and therefore, the period for den counts has been extended from mid-July - end of August (see Harrington *et al.* 2011) to mid-July - end September.

[38] The only complication that should arise will be if field signs become so prominent that they are essentially continuous (over more than 10 m) along the loch/river bank – if that becomes the case, record locations at 10 m intervals (e.g. for a 12-15 m stretch of feeding signs, record the first point midway within the first 10 m and then the second midway in the section that extends beyond 10 m.

[39] It is not necessary to predetermine the 10 m survey sections – this can be done retrospectively at the analysis stage to monitor e.g. changes over time in the proportion of survey sections containing foraging signs.

should be taken to show changes over time. To assess accurately whether a field sign is fresh or not, or been used recently, will require a degree of expert judgement, but assessments may be assisted by using an effective marking system to mark field signs when they are first recorded[40]. During Year 1 of the project a marking system was developed using natural wool to distinguish old (previously recorded) field signs from fresh field signs – this system is currently believed to be effective and so should be continued. Search effort for all surveys should be recorded.

Any reported or observed field signs (e.g. during searches for lost animals) outside the release area should also be recorded to provide information on dispersal.

Workplan — A strip of up to 40 m away from the water's edge around each loch/river known to contain beavers, as well as surrounding riparian corridors within the trial area (as shown in Fig. 2), should be searched for field signs each season (Spring = Mar, Apr, May, Summer = June, Jul, Aug, Autumn = Sept, Oct, Nov, Winter = Dec, Jan, Feb).

Data — Data should be entered into the existing revised field-sign file in the beaver trial database. For field signs recorded outwith the release area, any relevant explanatory notes should be added to the comments field (for example, known or suspected animal identification, any associated trapping efforts, animal now known or believed to be dead/alive, animal now rescued and returned to the release area).

Key information provided

The number and location of dams and lodges built
Territory locations, as well as number and size of territories
Territorial marking behaviour
Terrestrial habitat selection within territories

GPS telemetry

Overview — GPS telemetry is potentially able to provide a very detailed series of locations for beavers remotely and thus without the difficulties associated with observing beavers directly or with triangulation in VHF telemetry, and without significantly increasing the workload of the field team. Such data allow detailed analysis of (short-term) home range (and independent verification of home range boundaries as inferred from field signs) and, potentially (subject to limitations due to the precision of the data) habitat use, and could significantly help the ecological monitoring (both the quality of the data and the efficiency with which it can be gathered). Most importantly, GPS telemetry would provide data on nightly movements that we are otherwise currently unable to report on. Trials of inexpensive i-Got-U GPS loggers suggest that these tags would provide an affordable solution to the otherwise expensive GPS transmitters designed specifically for animal tracking. Preliminary trials show that locations are not recorded when the animal is inside the lodge but this is beneficial insofar as it, in effect, provides data on the times of emergence from, and return to, the lodge and thus, indirectly activity periods and schedules. Simultaneous deployment of GPS transmitters on animals from neighbouring lochs would also provide data on home range overlap (if there is any) that is impossible with the use of field signs alone. One disadvantage of the method is that animals have to be trapped twice, once to

[40] Markers used need to be able to persist in the environment for 1 to 2 months, but also not distract from the aesthetics of the area since Knapdale forest is located within a National Scenic Area open to visitors.

fit the tag and once to remove it to retrieve the tag (although one of these trap sessions can be part of the annual health monitoring trapping).

Workplan — Considering the animal welfare implications of repeated capture and handling of animals, the risk of loss of the tag, as well as the limited number of years remaining until the end of the trial, the decision was made to capture and tag only adults with the aim of tracking all adults over the following two years, with half the animals tagged in early summer and half in late autumn[41] (ensuring that there is even coverage of males and females in both seasons), each tracked for approximately two weeks. Ideally, all adults would be tracked in both seasons and the feasibility of this will be reviewed as the project progresses. Other sub-adults or non-breeding adults should be tracked opportunistically if the opportunity arises.

Data — Data should be provided in its raw format in a csv file as downloaded from the tag.

Key information provided

Independent verification of home range boundaries as defined by field sign locations (and potentially, spatial overlap with neighbours)
Distance and pattern of nightly movements
Activity patterns[42]
Habitat use[43]

Depth-temperature recorders (DTRs)

Overview — One unanswered question that still remains even if GPS tags are used, is to what extent beavers use the aquatic habitat. The resolution of GPS locations mean that it will not be possible to distinguish between a beaver on the land at the edge of the bank and a beaver in the water at the edge of the loch. Detecting aquatic habitat use from GPS data is also complicated by the fact that a fix will only be obtained if a beaver in the water is at the surface, but not all 'surfacing events' will be recorded due to the 15 minute fix interval. Since animals will now be trapped for GPS tag attachment, the opportunity exists to attach DTRs at the same time. DTRs are very small, light weight devices (31 mm length, 8 mm diameter, weighs 2.7 g in air and 1 g in water) that are capable of recording depth and temperature at 1 second intervals (for approximately 6 days), providing very detailed dive profiles. Whilst it may not be possible to distinguish between foraging dives and travelling dives, or dives approaching the entrance to the lodge, dive data will provide information on the amount of time spent in the water, which, coupled with known activity periods from the GPS data, will allow us to infer the proportion of 'active time' that beavers spend in the water.

Workplan — DTRs should be attached to animals alongside GPS transmitters, following the same schedule as for GPS tracking, with the same general aim of obtaining data from all adults over the following two years (half in each season – early summer and late autumn) or ideally, all adults in both seasons over the following two years.

Data — Data should be provided as raw download files (both the csv and BIN[44] files).

[41] although the ideal situation would have been to track animals over winter, the animal welfare implications of trapping animals in winter, and the difficulties posed to fieldworkers, meant that a more feasible solution would be to limit 'cold season' tracking to late autumn. Alternative methods of inferring activity times and/or movements in winter should be considered in future.
[42] as revealed by time of emergence from, and return to, the lodge
[43] subject to limitations due to imprecision inherent in these type of data

Key information provided

Time spent using the aquatic habitat
Dive depth, duration and frequency[45]

Surveys of otters and other riparian mammals

Overview — One of the qualifying features of the Taynish-Knapdale Special Area of Conservation (SAC) is the Eurasian otter (*Lutra lutra*) (which is also a UK BAP priority species). To demonstrate that the trial reintroduction of beavers into the SAC will not negatively impact on the site's qualifying features or on UK BAP priority species, otter presence in the area will be monitored over the duration of the project. Surveys for the presence of otter field signs will be undertaken by SNH following standard otter-survey methodology (see Appendix B). Supplementary data on the presence of mink field signs will also be recorded, since mink field signs are easily recorded alongside otter field signs, using the same methods. Further additional data on the presence of mink will be provided by SBT from their mink control activities.

Workplan — 20 surveys sites (10 in the release area and 10 in the control area) will be surveyed annually in autumn by SNH (ideally, but should be delayed if weather conditions are unsuitable). The survey should not be undertaken immediately after a period of high-water levels and should be completed in a single four-day period of fieldwork, rather than split into two. Survey site locations are given in Appendix B; the same sites will be surveyed each year. Samples needing their identification verified should be stored in a freezer.

Data — Data will be input into the riparian mammal survey data spreadsheet using unique section IDs that link to the survey sites in the GIS database. A record should be kept of all stored samples with IDs to allow links to survey data.

Key information provided

Presence, distribution and relative abundance of otters[46]

WORK-PLAN SUMMARY

Trapping — **Annual trapping - once per year targeting all individual animals, time of year to be decided by SBT, but should be reported, and (ideally) within the same season each year**

Kit trapping – September or as soon as possible after emergence from the lodge

Observations — **Data to be provided from SBT's monthly visual checks – one record per month for each individual.**

Lodge/den counts

Fortnightly evening (8-12 pm) observations of active lodges or dens, counting animals present when kits emerge (from approximately mid-July, through September).

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[44] These files can only be viewed using the datalogger HOST software provided by CEFAS, but are important for diagnostics should any problems occur

[45] Not necessarily part of the essential monitoring, but valuable biological data on beavers in loch systems

[46] It is not possible to assess habitat usage of otters from otter spraints

Field sign Surveys — **Surveys of known occupied areas and riparian corridors within the release area every season (Spring = March, Apr, May, Summer = June, July, Aug, Autumn = Sept, Oct, Nov, Winter = Dec, Jan, Feb) recording (and marking) all new field signs seen (within 40 m of the waters' edge of occupied areas).**

GPS Telemetry — **i-Got-U tags to be fitted to animals for 2 week periods with the aim of tracking, as a minimum, all adult animals over the following two years (half in early summer, half in late autumn).**

Depth-Temperature Loggers

To be fitted to animals alongside GPS tags.

APPENDIX B: MONITORING OF THE OTTER *LUTRA LUTRA* AND OTHER RIPARIAN MAMMALS - REPORT ON THE 2010 SURVEY

Monitoring of the otter and other riparian mammals was carried out by Rob Raynor at SNH. The full report on this aspect of the monitoring project (authored by Rob Raynor) is provided here; a summary of the collected data and a brief overview of the results is given in section 3 of the main report.

Introduction

The rationale for undertaking monitoring of otters and other riparian mammals at the release site is detailed in Campbell *et al.* (2010).

One of the qualifying features of the Taynish-Knapdale Special Area of Conservation (SAC) is the Eurasian otter (*Lutra lutra*). In order to ensure that the trial reintroduction of beavers into the SAC will not negatively impact on the site's qualifying features, a programme of monitoring, coordinated by SNH, is being undertaken and this includes for otter. In addition to the SAC issue, the monitoring will also provide a broad level indication of beaver effect on otter. Other riparian mammals, notably American mink (*Neovison vison*) and water vole (*Arvicola terrestris*) were included, as the former, at least, can be readily surveyed using the same methodology as for the otter. Both otter and water vole are UK BAP priority species and, if information on the occurrence of latter can be collected at the same time, this can only be beneficial, as the current distribution of water voles in Scotland is still incompletely known. Notwithstanding this, given the important ecological role that beavers play in the influencing the hydrology of their habitat and the experience from elsewhere in their European range, negative impacts from beavers on any of these other species are considered unlikely.

The fieldwork

The protocol for site selection and the fieldwork methodology are described in the first (2009) riparian mammals monitoring report (Harrington *et al.* 2011). Most sites are associated with bridges or obvious physical features such as loch outflows. Digital photographs were taken of each survey section, from the initial point of access and a GPS 10 figure grid reference recorded for the position at which the photograph was taken, (a table of photograph metadata is held by SNH). The direction in which the camera was pointing was recorded as "upstream" or "downstream", with the exception of one coastal site (7) where it was recorded as looking south.

At most sites, it was possible to conduct the survey by walking within the watercourse channel and recording any field signs observed from there. In very narrow watercourses, both banks could be inspected simultaneously, whereas at others it was necessary to survey each bank separately and/or complete part of the survey from the bank. In both 2009 and 2010 two of the larger watercourses (sites 3 and 16) were surveyed along one bank only.

The length of each survey section was estimated by counting paces as the survey progressed. The following field signs were recorded: holts/dens/places of shelter, spraints/scats, footprints/tracks and otter paths. Any evidence of prey was also recorded. The distance from the start to the first evidence of otter was recorded.

Although the recommendation in 2009 was that all fieldwork should be undertaken in a single 4 day block, this proved to be impractical and the fieldwork was again undertaken in two blocks: 6-8 October and 9-10 November. Each 100m section was walked, noting any signs of otter, mink or water vole.

Practical constraints

All but one of the sites in the control area was surveyed in early October prior to the main leaf-fall. The majority of sites in the trial area were surveyed a month later when leaf-fall might have been expected to affect the detection rate in some locations. However, this did not appear to be an issue as the number sites with evidence of spraint was the same as in 2009 and there was considerably more evidence of sprainting activity in 2010 (Table 3).

Most of the trial area sites were surveyed following recent heavy rainfall and at several sites water levels were still very high. This was particularly noticeable at Site 15 – the outflow of Loch Linne (Fig. 3) – and may have accounted for the negative result at the site.

Trial Area Sites

Figure 1: Site 14 Gariob

Figure 2: Spraint pile at Site 17

Figure 3: Site 15 outflow of Loch Linne

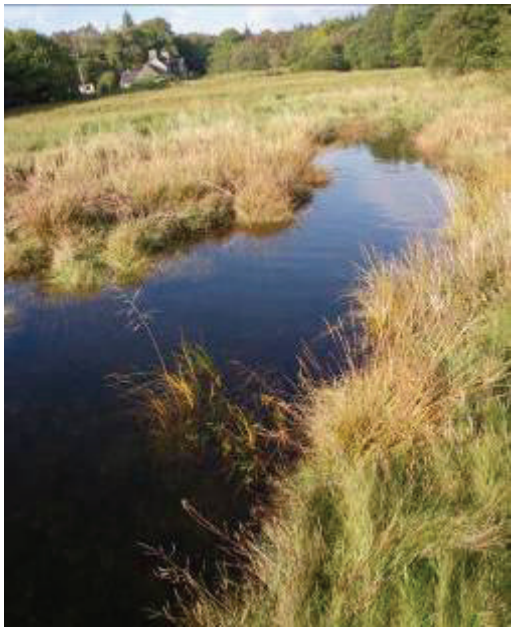

Figure 4: Site 17 Seafield

Figure 5: Site 13 outflow of Loch Coille Bharr

Figure 6: Site 18 outflow of Loch Creag Mhor

Control Area Sites

Figure 7: Site 9 tributary of River Add

Figure 8: Site 10 outflow of loch at Feorlin

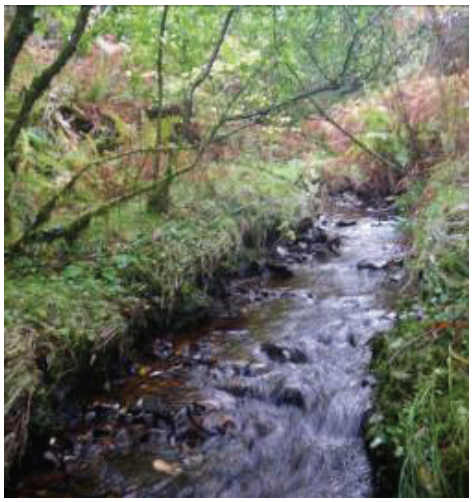

Figure 10: Site 5 A83 at East Kaimes

Figure 11: Site 1 Dippin Burn

Figure 9: Site 4 d/s of Loch Loran

Figure 12: Site 3 River Add

Results

The results of the survey are summarised in Table 2. Most field evidence was in the form of spraints and otter paths/runs.

Evidence of otter activity was confirmed at seven sites (70%) in each of the trial area and the control area. This represents a slight reduction on 2009 when the figure was 80% in each of the trial area and the control area. Perhaps more significantly, the *quantity* of spraint found at five of these positive sites was substantially greater than any of the positive sites in the control area, possibly suggesting a higher overall level of otter activity in these areas (Table 3).

The mean number of spraints recorded for all positive sites *where spraint was found* in both 2009 and 2010 is given in Table 3. Spraint evidence in the control area was markedly lower (40% of sites) than the trial area, but clear otter paths were visible in three other sites where spraint was not found, hence the comparable overall figure for otter presence.

Mink sign was confirmed at one site (below Loch Glashan Dam), where mink evidence was also found in 2009. Another possible mink scat was found at Site 4, also in the control area. No mink evidence was found on the mink raft at the outflow of Loch Creag Mhor (Site 18), nor at the outflow of the nearby Loch Linne (Site 15) in the trial area, although mink evidence was subsequently reported by the SBT Beaver Trial Officer from the latter site in March 2011.

No evidence of water voles has been detected, but this is not surprising given the autumn survey dates and the heavily shaded habitat at many of the locations. Note that the survey protocol was not really intended for this species, but any evidence would have been recorded.

There was evidence of otters moving up the Barnagad Burn in the form of crustacean remains (probably crabs) found in two spraints at Site 20.

Rob Raynor
Policy & Advice Officer (Mammals)
Scottish Natural Heritage

20 May 2011

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Table 1: Location of all survey sites inside the trial area (Y) and outside (N)

Site no.	x	y	Inside_trial_area	Description	Location	National_site
1	188600	690900	N	100m downstream d/s of track	Inland	N
2	194500	692400	N	100m d/s of road bridge	Inland	Y
3	191200	694800	N	100m d/s of track	Inland	N
4	191200	690200	N	100m upstream of entrance to un-named pond/lochan	Inland	N
5	191700	689200	N	100m d/s of road bridge	Coast	Y
6	192600	691500	N	100m d/s of road bridge	Coast	Y
7	191700	686600	N	100m south of landward end of pier	Coast	N
8	192000	692700	N	100m d/s of dam	Freshwater loch	N
9	193300	695800	N	100m d/s of fish ladder	Freshwater loch	N
10	195300	697000	N	100m d/s of dam	Freshwater loch	N
11	178900	691000	Y	Burn near L. Barnluasgan - d/s from road	Inland	Y
12	176700	688700	Y	coastal burn u/s from shore	Coast	N
13	177800	689700	Y	outflow from L. Coille-Bharr	Freshwater loch	N
14	178100	689100	Y	d/s from bridge - By Gariob cottage	Inland	Y
15	179400	690500	Y	outflow from L. Linne	Freshwater loch	N
16	177300	687700	Y	100m d/s of road bridge by L. Craiglin	Coast	N
17	177900	687600	Y	up un-named coastal burn from shore	Coast	N
18	180200	690800	Y	outflow from L. Creagmhor	Freshwater loch	N
19	179000	689200	Y	d/s confluence of 2 un-named burns, by ford	Inland	N
20	178200	686900	Y	d/s confluence of Barnagad Burn and Alltan Ghabhar	Inland	N

Table 2: Riparian mammal evidence, October and November 2010

Date	ID	Surveyor	Osight	Ospraint	ORP	OTR	Distance to first otter sign (metres)	Msight	Mscat	MT	Mother	Wsight	Wlat	Wother	Notes
08/10/2010	1	RR	0	0	0	?	-	0	0	0	0	0	0	0	Probable otter path, but no other signs to confirm
07/10/2010	2	RR	0	0	0	0	-	0	0	0	0	0	0	0	2 potential lie-ups, but no other signs to confirm
07/10/2010	3	RR	0	0	0	2	9	0	0	0	0	0	0	0	Also, potential lie-up, but no other signs to confirm
08/10/2010	4	RR	0	3+	0	1	30	0	?	0	0	0	0	0	Possible mink scat
06/10/2010	5	RR	0	0	?	2	11	0	0	0	0	0	0	0	Probable lie up, but no other signs to confirm
06/10/2010	6	RR	0	0	1	1	70	0	0	0	0	0	0	0	Holt at NR92640 91464 (old, disused?)
07/10/2010	7	RR	0	1	0	1	17	0	0	0	0	0	0	0	
07/10/2010	8	RR	0	0	0	0	-	0	1	0	?	0	0	0	Mink scat at 10m. Also, possible old mink den
07/10/2010	9	RR	0	1	0	1	55	0	0	0	0	0	0	0	Numerous potential lie-up sites. Old spraint
10/11/2010	10	RR	0	1	0	?	97	0	0	0	0	0	0	0	Old spraint
08/10/2010	11	RR	0	12	0	0	0	0	0	0	0	0	0	0	At least 12 spraints, including anal jelly
09/11/2010	12	RR	0	2	0	?	45	0	0	0	0	0	0	0	Possible path. V. fresh spraint at 45m
09/11/2010	13	RR	0	1	0	0	1	0	0	0	0	0	0	0	Old spraint. V. high water level
08/10/2010	14	RR	0	9	0	0	30	0	0	0	0	0	0	0	7/9 spraints were old
09/11/2010	15	RR	0	0	0	0	-	0	0	0	0	0	0	0	
09/11/2010	16	RR	0	8+	1	1+	6	0	0	0	0	0	0	0	Numerous paths. Holt on opposite bank to survey section (LHB)
08/10/2010	17	RR	0	8+	0	1+	23	0	0	0	0	0	0	0	6+ fresh spraint at 23m
09/11/2010	18	RR	0	0	0	?	-	0	0	0	0	0	0	0	Possible otter path, but no other signs to confirm
10/11/2010	19	RR	0	0	0	?	-	0	0	0	0	0	0	0	Possible otter path, but no other signs to confirm. V. few obvious sprainting sites. Beaver evidence. Frosty
10/11/2010	20	RR	0	4+	0	?	10	0	0	0	0	0	0	0	2 spraints were v. fresh and contained crustacean remains. Several potential lie-ups, but no other signs to confirm. Frosty

ID = Transect identification number, Osight = otter sighting, Ospraint = otter spraint, ORP = otter resting place, OTR = otter track, Msight = mink sighting, Mscat = mink scat, MTR = mink track, Mother = mink other field sign, W = water vole sighting, Wlat = water vole latrine, Wother = water vole other field sign. Surveyor RR = Rob Raynor.

Table 3: The mean number of otter spraints recorded for all sites where spraint was found

	2009		2010	
	Proportion of sites with evidence of otter spraint	**Mean no. spraints per site (where spraint was found)**	**Proportion of sites with evidence of otter spraint**	**Mean no. spraints per site (where spraint was found)**
Trial area	7/10	3.9	7/10	6.3
Control area	6/10	1.3	4/10	1.5

APPENDIX C: MORPHOMETRIC DATA

Data are weight (kg), head-body length (cm), tail thickness[a] (cm)

Animal	Age (years)	Pre-release	1 year post-release	2 years post-release
Bjornar	(adult)	-	-	20.4, 79.5, 2.64
Katrina	(adult)	15.9, -, -	21.0, 81.0, 1.93[d]	19.5, 78.0, 2.30[e]
Mille	2	-	16.4, 68.0, 1.90[c]	Not caught yet
Frid	(adult)	19.4, 77.5, 2.33	21.4, 77.0, 2.43[b]	20.0, 76.0, 2.29[e]
Frank	(adult)	12.1, 77.0, 2.36	19.4, 78.0, 1.70[b]	21.0, 81.0, 1.89
Biffa	2	10.9, 64.0, 1.56	13.9, 70.5, 1.62[b]	Animal missing
Trude	2	9.1, 66.0, 1.5	Not caught yet	[f]
Eoghann	2	14.5, 75.0, 1.62	14.5, 73.0, 1.69[d]	[f]
Elaine	2	12.5, 71.0, 1.67	13.5, 69.0, 1.77[d]	[f]
Christian	3	16.5, 80.5, 1.85	[f]	[f]

- Data missing

[a] Measured as the mean of four separate measures taken from four standard points on the tail (details in Campbell *et al.* 2010).

[b] Measured at 6 months post-release.

[c] Measured at 8 months post-release.

[d] Measured at 10 months post-release.

[e] Measured at 1 year, 9 months post-release.

[f] Animal not been released this long.

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