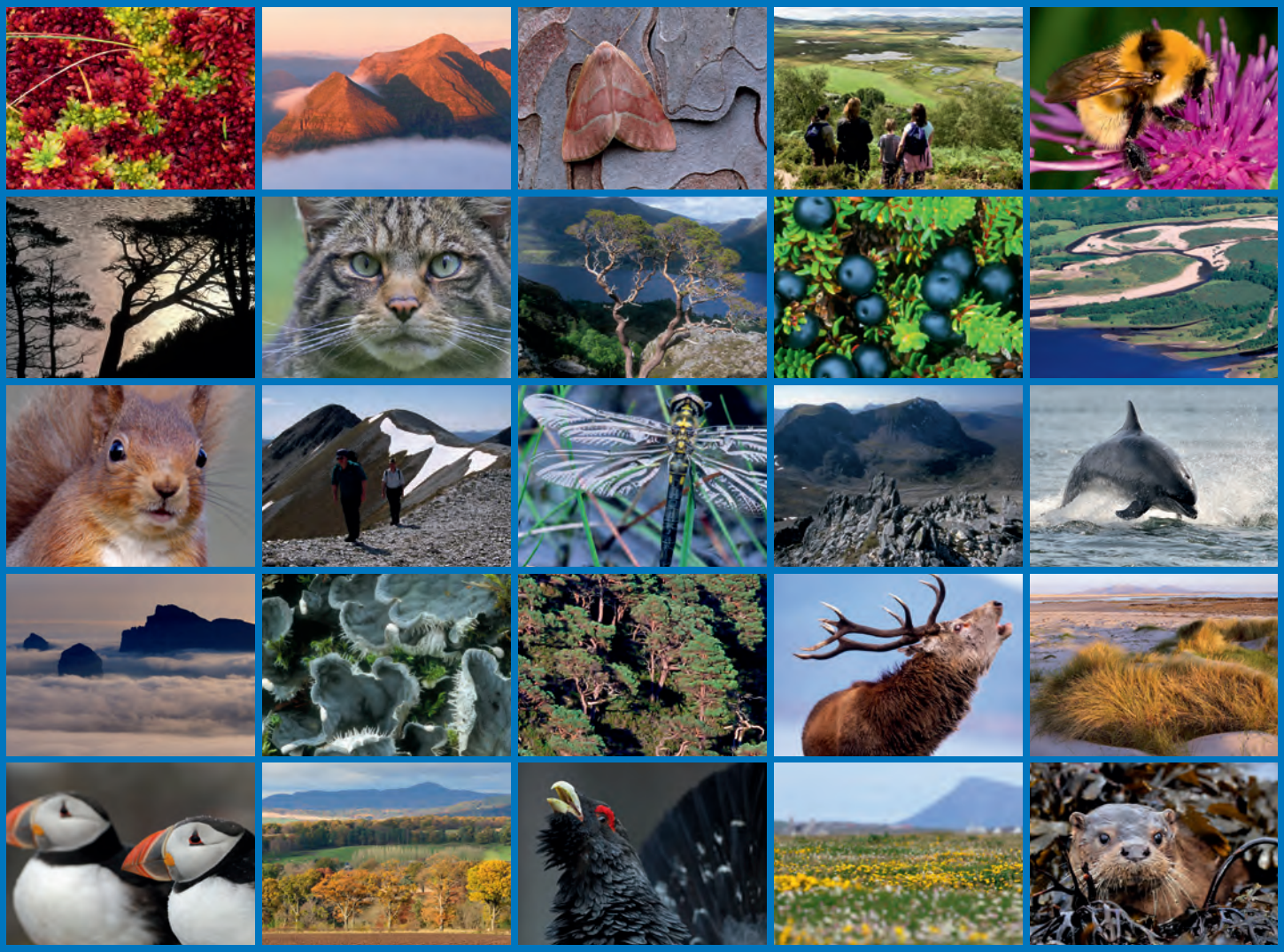
Scottish Natural Heritage
Commissioned Report No. 560

Pine martens on the Isle of Mull – Assessing risks to native species



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COMMISSIONED REPORT

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Pine martens on the Isle of Mull – Assessing risks to native species

For further information on this report please contact:

Colin MacFarlane
Scottish Natural Heritage
Cameron House
Oban
ARGYLL
PA34 4AE
Telephone: 01546 603611
E-mail: colin.macfarlane@snh.gov.uk

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COMMISSIONED REPORT

Summary

Pine martens on the Isle of Mull – Assessing risks to native species

Commissioned Report No: 560
Project No: 12989
Contractor: FERA: S. Roy, J. Milborrow, J. Allan and P. Robertson
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Background

A population of pine martens has recently been discovered on the Isle of Mull, with a number of sightings, the collection of faecal material, the discovery of a carcass and a breeding event recorded since the late 2000s. The source of this population is unknown, as is the likely date of arrival.

This report looks at whether or not martens have ever existed on Mull and when and how they are likely to have arrived. It assesses the likelihood of the species spreading and establishing itself on Mull, and the impacts it could have on the native fauna of the island.

Mull has a paucity of competing carnivore species, sufficient denning habitat and prey availability in the form of voles to sustain a marten population. Martens could potentially prey upon a number of species of conservation concern, including bird and reptile species.

These impacts have not yet been documented following the recent arrival of pine martens on the Isle of Skye, where predation by foxes is apparent, although as yet, predation by foxes does not appear to be having any population level impacts. Although Mull lacks foxes, American mink are present on the island pressurising some native bird species. The potential effects of an additional predator in combination with this may have disproportionately deleterious effects.

Main findings

- Based on available evidence, it is unlikely that pine martens have ever been native to Mull.
- Based on sighting records, and from resulting modelling exercises, the species is believed to have arrived in 2004.
- The most likely route of entry is through accidental transportation on timber boats from the mainland.
- The species is now believed to be present over a wide area either side of Craignure in the east, and is likely to spread as it has on Skye, an island with similar habitat types. Using Skye as a comparator, the species has spread approximately 40-50 km in 15 years.
- As the island has a paucity of competing carnivore species, sufficient denning habitat and prey availability in the form of small mammals and birds, the species is highly likely to establish and spread throughout the island.

- Mull has a suite of bird species listed under several conservation categories, many of which could be impacted by martens. These have been listed and categorised. These impacts have not yet been documented on Skye, where predation by foxes is more apparent.
- Although Mull lacks foxes, some bird species such as waders, waterfowl and ground nesting sea birds, may already be impacted on Mull by another invasive predator, the American mink. The potential effects of an additional predator on some vulnerable species may have disproportionately deleterious effects.
- The most devastating impacts would be seen if the species reached seabird colonies on the offshore islands of Treshnish and Staffa, but this is seen as a highly unlikely event.
- Longer-term ecosystem level impacts are harder to predict, but have been seen on islands where the species has been present for long periods of time, such as the Balearics.
- Martens may have negative economic impacts on poultry raised in crofts, and on the game bird industry. They may have positive impacts on the eco-tourism industry however.
- A range of management options are available. These include the eradication of this species from the island; localised control to reduce damage or limit spread, or non-intervention.
- Alongside any management, collecting more data on species numbers and distribution would help guide the decision and cost of different management options. This data could be collected through a range of low cost techniques such as camera trapping, scat surveys and the collation of sighting information.

For further information on this project contact:
Colin MacFarlane, Scottish Natural Heritage, Cameron House, Oban, Argyll, PA34 4AE.
Tel: 01546 603611 or colin.macfarlane@snh.gov.uk
For further information on the SNH Research & Technical Support Programme contact:
Knowledge & Information Unit, Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or research@snh.gov.uk

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Acknowledgements

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1. INTRODUCTION

1.1 The presence of pine martens on Mull

1.1.1 Background to the project

Mull currently has a population of pine martens (*Martes martes*), with faecal material being recorded since March 2008 (M. Wilson pers. comm., D. Sexton pers. comm.) and formal sightings since May 2010. A breeding event in the roof space of a building in the main port of Craignure has also been recorded in the summer of 2010 (P. Brown, Discover Mull pers. Comm.).

It is unclear whether or not pine martens have ever naturally occurred on Mull and therefore whether this could be a relict population. Alternatively this population may be the result of an accidental or deliberate introduction. If the latter, more information is needed to determine whether or not the species is likely to become invasive and the kinds of impacts they may have on native wildlife and the local economy.

Like most offshore islands, isolation coupled with a reduced mammalian carnivore species results in Mull and its offshore islands being a biodiversity hotspot (Cronk, 1997), particularly for ground-nesting birds such as corn crakes (*Crex crex*) and seabirds such as puffins (*Fratercula arctica*) (Mitchell *et al*. 2004).

Over the last century the pine marten has suffered a huge range contraction across Britain, mainly due to persecution in the past through game keeping and habitat loss; in particular the loss of old-growth forests with adequate denning sites (Harris, 2008). In Britain pine martens are protected under the Wildlife and Countryside Act 1981 (as amended).

The species is confined mainly to Scotland, with a few relict populations in Northern England and North Wales (Harris and Yalden, 2008). Through legal protection, a reduction in game keeping practices and the creation of suitable habitats under forestry schemes, pine martens have recovered and recolonised a substantial proportion of their former range in Scotland (Caryl, 2008; Halliwell, 1997; Summers *et al*., 2009). The North and West of Scotland remained a stronghold for pine martens, with some local high-density populations (Velander, 1983). Some areas, such as the Ardnamurchan peninsula close to Mull are believed to have high densities of martens (M. Wilson pers comm.). Along with this range expansion and recolonisation, the species appears to have colonised a number of new areas, including newly accessible offshore islands such as Skye after the construction of a bridge, and now Mull, which are of immense value as biodiversity hotspots at the National and European level.

The main aims of this project therefore are as follows:

- To determine whether or not pine martens have ever existed on Mull from historical records and from expert opinion, and if not, how they may have arrived on the island. Where data allow, models will be used to extrapolate and look at possible population sizes and dates of arrival of the species onto Mull.
- To explore the distribution and impacts of pine martens on other islands to which they have been introduced.
- To look at the current distribution and population size of the species on Mull based on sightings and records of signs.
- To assess how the species is likely to spread over the island based on habitat suitability and prey availability.

- To evaluate the impacts they may have on native vertebrates of conservation concern, both directly and indirectly, and the potential economic impacts of the species.
- To explore the different management options available.

1.1.2 Historical records of martens on Mull and on other Scottish islands

Due to their nocturnal nature, together with the fact that the species prefers old-growth forest where available (Brainerd, 2002), and that historically, human populations in the Highlands and the West Coast of Scotland have been small, pine martens may be under-recorded in the wild. As a result, there is a paucity of information on their distribution and abundance, especially in historical records (A. Kitchener pers. comm.). A lot of the written historical data are recorded at county level, with the offshore islands under-represented, adding to the lack of information. With the increase in the human population, together with homeowners feeding martens, sightings of this species have been increasing.

Pine martens are not recorded as being on Mull according to the Old Statistical Record of Scotland (Sinclaire, 1800). Pine martens have been recorded in Oronsay in archaeological records. They may also have been present on Colonsay, Jura and Islay according to some of the place names on the islands (Mellars, 1987).

The consistency of the Old Statistical Record of Scotland is questionable however, as it records foxes (Vulpes vulpes) historically occurring on Mull. This species does not currently occur on the island, and yet there is no mention in the literature of foxes having been exterminated. Information in the historical record should also be treated with caution, as archaeological information is based on bones found in middens, which are refuse piles usually associated with food waste, which pine marten remains are not.

To confuse matters further, the fur of medium sized mustelids such as pine martens was highly valued in Mesolithic times, and also by Viking travellers, and it is highly possible that live animals were moved around and introduced to novel regions across Europe to provide a trappable fur. This may well be the source of some of the historic Scottish island populations such as that recorded in the Outer Hebrides, with the Isle of Lewis being the closest point to the Scottish mainland at a distance of approximately 33km. Martens became extinct here in 1875, most likely as a result of game keeping activities (Langley and Yalden 1977). Deliberate introduction is also the probable reason for marten populations existing on the Balearic islands (Clevenger, 1993), although some of the Mediterranean island populations (such as the one on Sardinia which is regarded as a distinct subspecies) are probably native there (Colli *et al*., 2011).

1.1.3 Museum records

There are no pine marten specimens or records of specimens collected from Mull or Iona in any of the major national museums, such as the Natural History Museum in London, Tring (Hertfordshire), Edinburgh, Manchester, and collections housed by Universities such as Aberdeen, Oxford and Cambridge. Both Dr Andrew Kitchener of the National Museums of Scotland and Professor Clive Bonsall at the University of Edinburgh were unaware of any specimens collected from Mull being stored in any museum collections in the UK.

1.1.4 Expert elicitation

Twelve experts were selected from around the country on the basis of their experience in pine marten ecology, the ecology of Scottish islands, or their knowledge of the historical distribution of mammals around the UK. In order to maintain anonymity, the experts selected are not named in this report but are known to SNH staff. They were questioned by telephone

or by email and asked the questions listed below. Associated answers have been provided under each of the questions in Table 1 below:

- To your knowledge, is there any evidence of pine martens ever having existed on Mull or the surrounding islands historically?
- If not, are you aware of their presence there now?
- How do you think they got there?
- Will they spread and establish?
- What type of impacts do you think they will have?
- What management actions should be implemented in the first instance?

Plate 1. Dead marten found by S. Roy on Benbecula 2005.

Table 1. A summary of expert opinion on martens on Mull.

Question	Answer (% given from n=12)	Noteworthy comments
Have pine martens ever existed on Mull historically?	No. 83% Potentially. 17%	• Two experts are surprised that they are not on Mull. • They can remain undetected at low density, and may be unrecorded as a result. • They have been moved around leading to a record from Oronsay.
Are you aware of their presence there now?	Yes. 92% No. 8%	• Also on some of the surrounding islands such as Seil Island near Oban (Eilean Beagh) according to local intelligence.

How do you think they got there?	Deliberate introduction. 17% Accidental stowaway. 83%	• Martens are not recorded as swimming large marine distances
Will they spread and establish?	Yes but slowly. 58% Over time will become well established in the absence of competition and management. 42%	• Plenty of food available as rabbits (Lepus curpaeums) and voles (Microtus sp) are at high density on Mull
What impacts will they have?	Very little, should they remain at low density. 67% Potentially large on outer islands like Iona. 33%	• Potentially very large on marginal species such as divers (Gavia sp) and seabirds.
What management actions are needed?	Monitoring with a view to rapid deployment of active management options such as translocation. 58% Just monitor for now. 100% None. 42%	• They are relatively easy to trap or attract to bait. • Easy to recognise scats, especially as no confounding fox scats for confusion on Mull.

1.2 Summarising patterns of pine marten colonisation on Mull

1.2.1 Likely origins and arrival

i.)They have always been there but remained undetected

Although possible, it is highly unlikely that they have always been there but remained undetected as there is no record of them in the literature. In addition, despite years of stalking on Mull since the 1970s, M. Wilson (pers. comm.) has never found any evidence of them until the recent sightings. Also despite years of trapping mink (Neovison vison) and carrying out field work on Mull and its offshore islands, they have never been caught and no evidence of them has ever been gathered prior to the spate of sightings within the last decade. Martens are also generally absent from offshore islands (except for anecdotal evidence of their presence on Seil Island as discussed in Table 1). Pine martens have also been found on the island of Eriska near Oban, and DNA analysis subsequently has shown individuals to be genetically distinct from the rest of the mainland population and more similar to marten populations approximately 60 years ago (Vincent Wildlife Trust, 2011).

Based on the paucity of evidence, the collation of existing information, and on expert opinion, pine martens could have got to Mull in the three following ways:

ii.) They swam there from the mainland

It is highly unlikely that pine martens arrived on Mull by swimming from the mainland to the island, which at its closest point is 1.6 km. Although they can swim and have been known to swim to diver nests floating on rafts in freshwater (M. Wilson pers. comm.) they have never been recorded making sea crossings (R. Balharry, pers. comm.).

iii.) They were transported accidentally on boats

This is the most likely route of entry onto Mull. Pine martens have been known to stow away on timber boats (M. Wilson pers. comm.) and it is possible that individuals have done so on the many timber boats that come into Craignure from the west coast of Scotland. Evidence in support of this, is that some areas of the west coast have high density marten populations and wood and other goods are regularly shipped to and from Craignure where the first denning individuals were seen. Also M. Wilson (pers. comm.) has witnessed denning females on timber boats.

iv.) There have been deliberate clandestine releases.

Although possible, and often spoken of (together with clandestine releases in the 1980s of pure polecats (*Mustela putorius*) on the Scottish mainland (Anonymous, pers. comm.) there is no evidence for this. It is apparent though that with the large volume of vehicular traffic onto Mull, there are ample opportunities for unpredictable animal movements through human agency. A similar example of a pine marten (in this case a carcass) was seen on Benbecula in the Outer Hebrides in 2005, with a specimen being found by the author (Plate 1). It is highly likely however that this specimen was the result of a deliberate placement of a carcass, picked up on the mainland, and planted on the road to make it appear to be a road kill. Deliberately moving martens in this way contravenes the Wildlife and Natural Environment (Scotland) Act 2011, legislation which prohibits the "*release or allow to escape from captivity any animal to a place outwith its native range*". In addition, pine martens are also listed under Schedule 5 and therefore protected under the original Wildlife and Countryside Act 1981 (as amended). This prohibits capture, disturbance, killing, "taking" or selling pine martens.

1.2.2 Breeding events

In May 2010 a female pine marten was found denning in the roof of a kayak centre in Craignure (now a coffee shop). She was seen entering and leaving through a hole in the roof and is known to have raised at least two kits, although it may have been possible that she raised three. The number of young remains unconfirmed, and although this individual has been sighted on at least four occasions by several reputable wildlife personnel (D. Sexton pers. comm.), it has not been possible to procure photographic evidence. There have been no further confirmed breeding events, but there have been a number of sightings of individuals, groups of individuals and of faecal deposits. These are outlined in the next section.

1.2.3 Sightings and information from estates

Information on sightings was gathered from individuals on Mull from the sources below. A timeline of sightings is provided in Figure 1, while a map of sightings or evidence is provided in Figure 2.

- A Newspaper advert was placed in Round and About Mull, the local paper, with a phone number and email address where people could report sightings. One email report of a sighting was received and five phone calls were received providing details of sightings. A copy of the advert is provided in Appendix 2.
- Personal contacts provided by Jan Dunlop of the Mull Ranger Service and Dave Sexton of the RSPB were followed up and 16 personal phone calls were made as a result.
- A list of estate owners/managers was provided by Jan Dunlop and these were contacted by telephone. Of the 33 estates contacted, 13 replied to messages left, or answered the phone directly. Of these 13, 12 were unaware of martens being

present on Mull, and one had definite sightings of multiple individuals (N=3) in May-June 2010.

- The internet was searched using the programme Visual Web Spider by Newprosoft. Over 1.3 million web pages (including blogs) were found containing the key words terms "pine marten" and "*Martes martes*" to a depth of four levels. Of these 30,000 also referred to Mull. We then used text mining procedures modified by Fera (GATE. http://gate.ac.uk/). Text mining has the greatest impact where it is necessary to read large quantities (>20,000 abstracts/documents) of unstructured text from multiple domains, Internet, grey literature, internal e-libraries, and numerical databases, where the main purpose is to highlight text of a specific user-defined nature. Only two pages referred to martens on Mull, both relating to the BBC website following the series Spring Watch.[1] Otherwise this did not prove to be useful source of information.

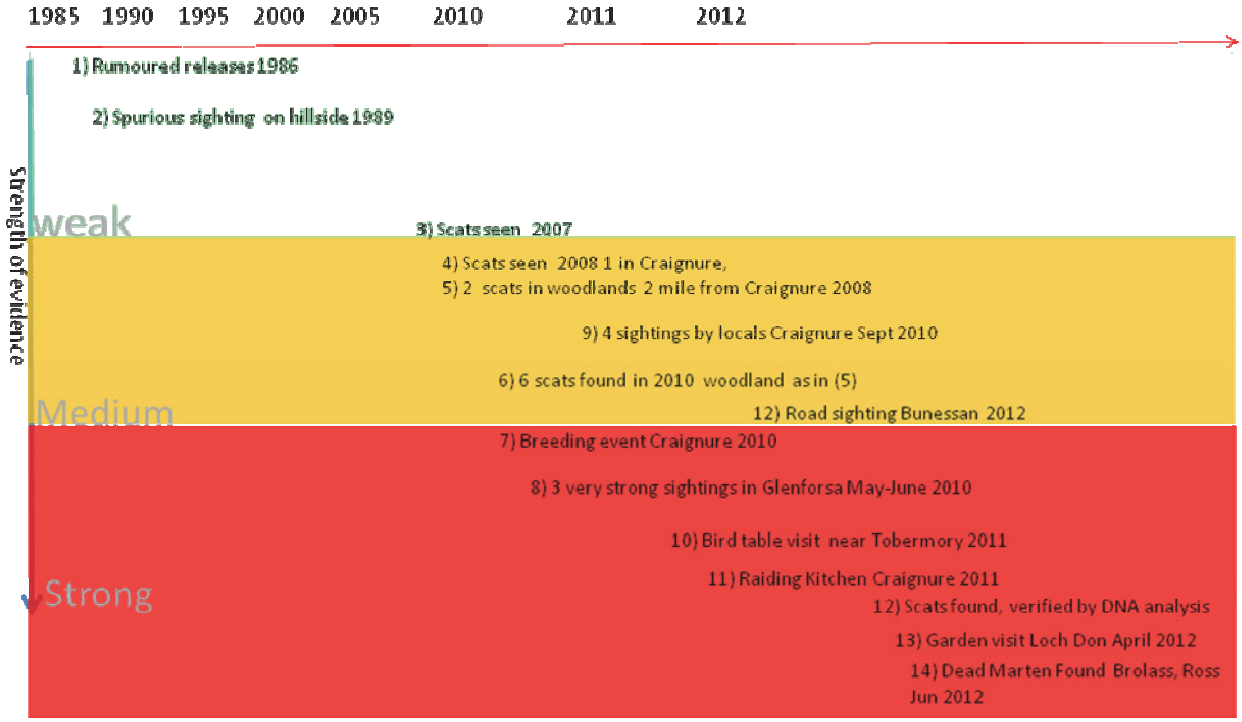

Figure 1. Timeline of sightings, scats and breeding events. Note, post 2010, the scale is more detailed. Evidence is numbered in sequential order.

[1] news.bbc.co.uk/1/hi/scotland/highlands_and_islands/6470777.stm

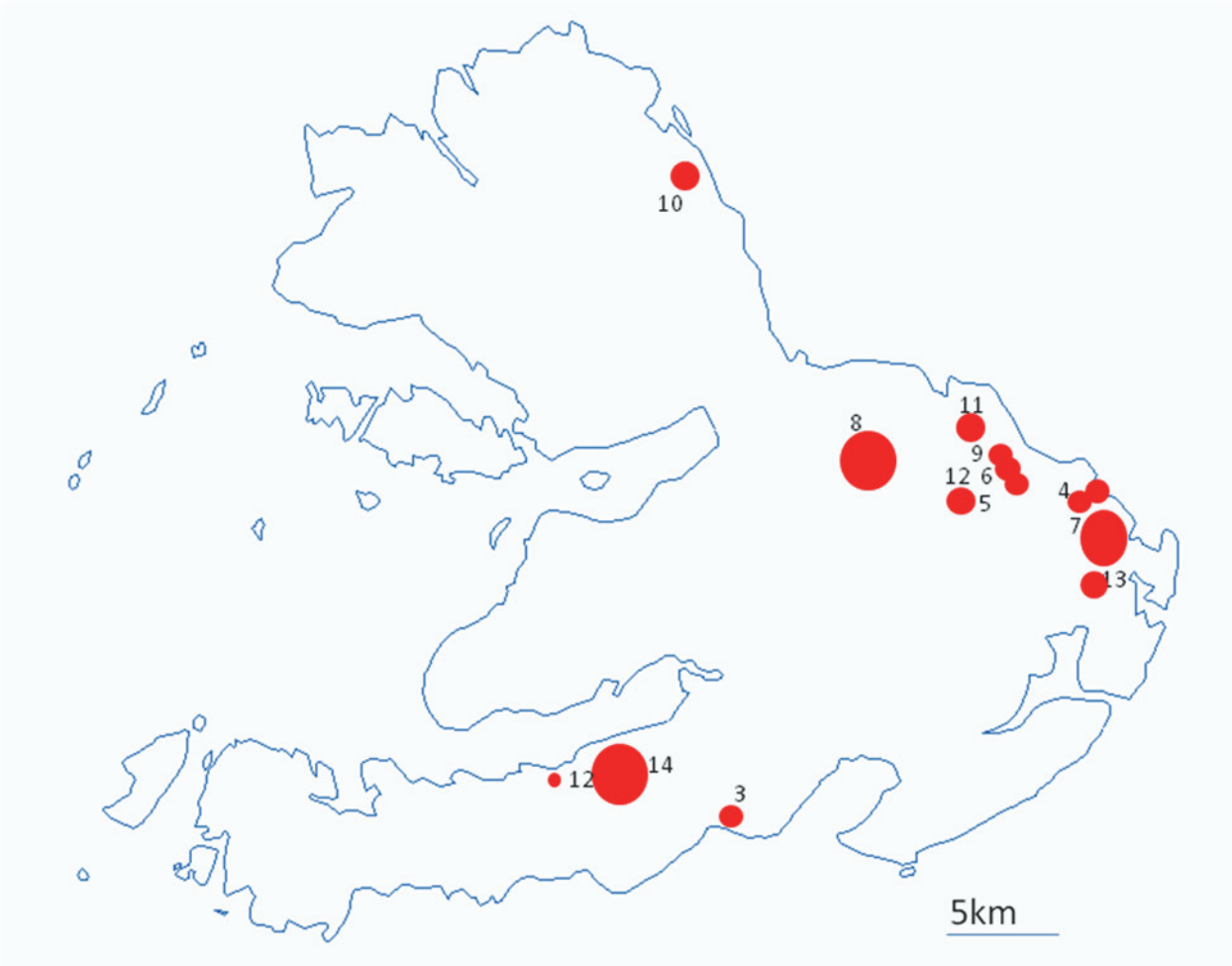

Figure 2. Sightings of martens or their scats on Mull. The size of the dot relates to the strength of the sighting, numbers relate to the sequence in Figure 1. Sightings before 2000 have not been included.

1.2.4 Likely spread

Mull, with a habitat very similar to much of the west coast of Scotland, is very suitable for pine martens to establish and spread (Caryl, 2008; Halliwell, 1997). It can be assumed, from scat evidence collected by reliable field workers (M. Wilson pers. comm.), that the species has been present on Mull for at least 2-3 years prior to the breeding event recorded in 2010. Scats and sightings have also been recorded up to 10-15 km either side of Craignure since, so it can be assumed that the species is ranging widely along this coast. Martens can colonise suitable habitats rapidly (Balestrieri *et al*., 2010), and although daily movements are highly dependent on food availability and habitat quality, martens can range long distances daily with home ranges over 900 ha (Zalewski *et al*., 1995), moving up to 15.8 km/day (Balharry, 1993; Caryl, 2008; Halliwell, 1997) and make good use of a wide range of linear features as movement corridors, including drainage channels and woodland edge (Clevenger *et al*., 2001). Since the construction of the Skye Bridge in 1995, martens have spread a long distance, having recently been recorded in Carbost, 40 km to the west. During this period the spread has been most rapid through wooded areas, and more slowly through moorland (R. Cottis pers. comm.).

The habitat on Skye is very similar to Mull, so a similar rate of spread might be expected. Also, the area in and around Craignure itself is highly wooded, and a mosaic of woodland,

scrub and moorland forms a meta-habitat that would enable the species to spread throughout Mull (Figure 3).

1.2.5 Likely populations

Mull has suitable habitat for martens, together with prey in the form of high density vole populations (Harris *et al.,* 2008). It also does not have foxes, a species which at high density normally suppresses marten populations (Lindstrom *et al*., 1995). In the absence of a full complement of competing carnivores, marten populations could reach high densities as seen in Scandinavia (Helldin 2000) where other carnivores have been temporarily removed through perturbations in the environment, such as logging. Having been present since 1995, the marten population on Skye is now crudely estimated to be just under 50 individuals, although the estimate is very rough (R. Cottis pers. comm.). This is despite the presence of a fox population on Skye, although this is well controlled by keepers. It should also be noted that martens still regularly cross the Skye Bridge, and hence there is still a constant colonisation pressure, as opposed to the occasional stowaway on a boat as may be the case on Mull. It is currently not possible to give an accurate estimate for the marten population on Mull, although there are probably less than 20 individuals. This is purely a subjective estimate based on sighting records, and more research is necessary to determine this. As females can breed in their second year, and with a potential litter size of 3-5 young every year up to ten years of age or more, this species has the capacity to establish and grow quickly. Some animals in Eastern Europe have been reported living for 17 years or more in the wild and breeding up to 15 years of age (Harris *et al.,* 2008).

1.2.6 Presence/absence models and arrival estimates

Reconstructing the history of the introduction of a non-native species to a particular location or habitat can be important to both science and management. There is however, uncertainty about when martens actually arrived on Mull. This uncertainty is magnified by the fact that even now the presence on Mull of this nocturnal, rare and elusive species is known only through occasional chance sightings. Data on sightings were supplied to Dr David Roberts (University of Canterbury in Kent) to establish whether they were of sufficient quality to model potential arrival dates of the species. Here, the term sighting is not restricted to visual sightings of individuals, but can include other forms of evidence of the presence of a species such as tracks, hair, and faecal matter. Dr Roberts and colleagues are experts on predicting extinction rates for rare species.

Statistical inference about the introduction time of a non-native species from a record of its sightings is the mirror image of inference about the extinction time of an extinct species based on its sightings. Thus models established by Solow (1993); Solow *et al*., (2006), used to predict extinction rates for globally rare species were modified to establish potential colonisation dates for martens on Mull. This is similar to a model developed to establish whether a recently discovered polecat population in north-west Scotland was a relict population or a newly introduced one (Solow *et al*., 2006).

The data were subjected to the following procedure:

- An estimated arrival date was set and the rate of sightings after this date was recorded.
- Based on sighting “rate”, the likelihood of martens being introduced in that set year was calculated.
- If this “rate”, which depends on factors such as the size of the population and sighting effort, is low, then even a relatively long period without sightings does not imply that the species was absent. Conversely, if this rate is high, then even a relatively short period without sightings implies that it was.

- Sightings were therefore weighted according to their relation to a truncated exponential distribution with a probability density function. In other words each new sighting adds weight to the previous one.
- The process was reiterated for subsequent years being set as the estimated year of introduction.

Table 2. Estimated dates of arrival, together with associated earliest and latest dates, and p-values for those dates.

Earliest arrival date	Estimated year	Latest arrival date	P values	Comments
Feb 1974	May 1978	Sep 1982	1.000	Not significant
May 1987	Jun 1990	Feb 1992	0.054	Only just not significant
Aug 1993	Jan 1995	Jan 1998	0.021	Significant
Oct 2002	May 2004	Jan 2006	0.001	Highly significant

The results of the model give an earliest possible arrival date and a latest possible arrival date around every potential arrival year. The significance of the arrival year is also given, based on the pattern of sightings after the introduced date. These are presented in Table 2. The wider the interval between earliest and latest dates surrounding a given year, the more uncertain the data. Also, only the last two values provided statistically significant results, with the last one giving very significant results. Based on this, it is suggested that martens arrived on Mull between 2002 and 2006.

2. HABITAT SUITABILITY

2.1 Habitat suitability and denning requirements

Martens are able to make use of a wide variety of habitats, and as long as there is suitable prey available in the form of microtine rodents, can vary their habitat usage to woodland, moorland, scrub and even agricultural vegetation (Clevenger, 1994; Thompson, 1994; Kurki *et al*., 1998; Clevenger *et al*., 2001; Brainerd and Rolstad 2002; Rosellini *et al*., 2008; Cervinka *et al*., 2011). The main habitat divisions of Mull, adapted from Land Class Monitoring data (CEH, 2000) show there is a high proportion of wet heathland with pockets of woodland and scrub throughout (Figure 3). The map does not show presence of new forestry on the island which postdates the 1997 survey. The main limiting factors on marten distribution are the presence of predatory or competitive carnivores such as foxes, which are absent, and the availability of den sites (Birks *et al*., 2005). Martens can den in a variety of sites however, such as in old-growth forest trees, rock piles and in loft spaces of residential buildings (Birks *et al*., 2005), all of which are available in Mull in abundance.

Mull has a habitat very similar to much of the west coast of Scotland, which has a well-established marten population. Also, if the pattern of marten expansion on Skye is to be used as a predictor as to how the species will behave on Mull, martens should be able to spread through all of Mull, as there is plenty of old growth forest, forestry providing cut trees; in turn providing log and brash piles for denning and thermoregulation, and vole-rich moorland.

Martens are able to make use of a wide variety of corridors for movements, such as water drainage channels, hedges, woodland edge and riparian gallery forest (Clevenger *et al*., 2001) all of which are in abundance on Mull. Martens should be able to colonise all ‘mainland’ areas of Mull using these features.

2.2 Food availability

Martens are able to make use of a wide variety of prey including small mammals, birds and fruit (Jedrzejewski and Jedrzejewska 1993; Clevenger, 1995; BenDavid *et al.,* 1997; Helldin, 2000; Putman, 2000; Lynch and McCann, 2007, Caryl, 2008) and can also vary their diet according to seasonal fluctuation in prey (Clevenger, 1995; BenDavid *et al*., 1997; Helldin 2000). Mull has a high density of voles which could support a viable marten population (Caryl, 2008). This is supported by the presence of breeding hen harriers (Circus cyaneus) and short eared owls (Asio flammeus) on Mull which fluctuate with vole availability (Korpimäki *et al.* 2005). Commercial conifer forestry operations in particular can sustain high vole populations (Charles, 1981). There are also sufficient populations of wading birds and rabbits and potential for scavenging from larger predators such as otters (Lutra lutra) and eagles (sea eagles (Haliaeetus albicilla) and golden eagles (Aquila chrysaetos)). Food is not in short supply and so a scarcity of food is unlikely to limit marten population expansion on Mull. In addition, a large number of householders feed garden birds at bird tables, which martens frequent on the mainland. This would provide a high calorie food source for martens. It would also allow monitoring of marten populations (discussed later).

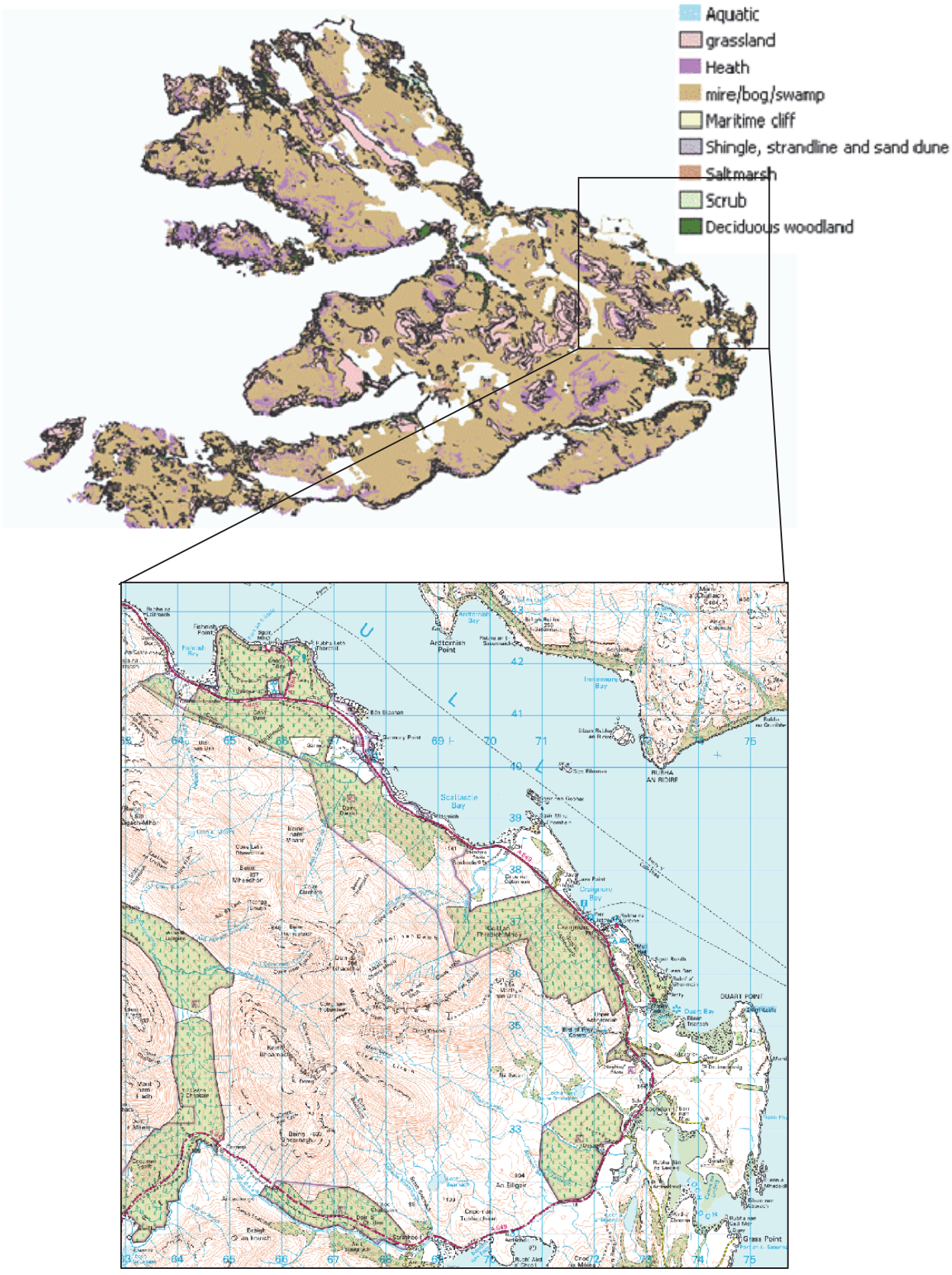

Figure 3. The main habitat types on Mull showing the presence of forestry stands in close proximity to each other in the areas where martens have been recorded, highlighting the availability of suitable habitat in the area. © Crown Copyright and database right [2012]. All rights reserved. Ordnance Survey Licence number 100050926.

3. IMPACTS

3.1 Birds

3.1.1 Likely impacts on prey - birds

Mull and its offshore islands are the location of several Special Protection Areas (SPAs) (Figure 4.). The main SPA on the mainland of Mull is designated for golden eagle; a species that is unlikely to suffer predation from martens. The designations for the offshore islands of Treshnish and Staffa are for nationally important seabird populations, while Glas Eileanan is an important SPA for common tern (Strena hirundo). These would be threatened by martens if the species ever made it there through swimming (unlikely across stretches of sea, based on section 1.2.1), or through stowing away on boats.

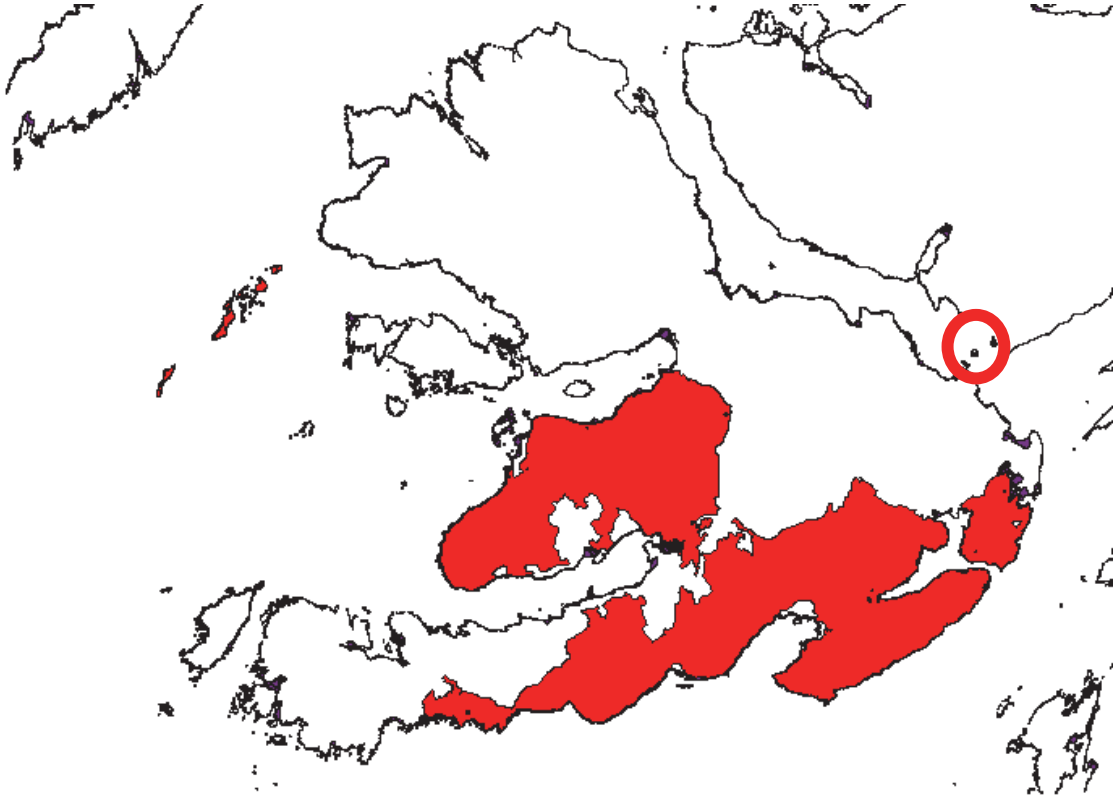

Figure 4. The SPAs on Mull, showing the main site on the mainland of Mull, the Treshnish Isles important for their seabird colonies, and Glas Eileanan in the Sound of Mull, an important site for ground nesting seabirds. The latter has been circled to highlight it due to its size.

However, Mull is an important island for several bird species that are listed under different conservation categories, and martens may prey on these. To assess this risk, bird species were selected by the following methods:

1. Species were selected if they occurred as a "bird species of conservation concern" (Eaton *et al.,* 2009), a UK Biodiversity Action Plan (UK BAP) "red listed species"[2] or on Annex 1 of the EU birds directive,[3] and also occur on Mull as a breeding species

[2] This is taken from http://jncc.defra.gov.uk
[3] DIRECTIVE 2009/147/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, 30 November 2009, on the conservation of wild birds

on the basis of information given in the Argyll bird reports (Callan (ed.) 2012) and the Atlas of breeding birds (Gibbons *et al.,* 1994).

2. Species were then scored on their conservation status. If a species is of conservation concern (red-listed) it was given a score of three, as this has the most relevance at the local scale. A red-listed species under the UK BAP scheme is given a score of two, as this has the most relevance at the regional scale. If it is listed as an Annex 1 species under the EU Birds Directive, it is given a score of one as it has relevance at the national scale.

3. These three scores were then summed to produce a total 'conservation concern' score between 0 and 6.

4. In order to assess the likely level of impact of pine martens on the different species identified in step 1, a further factor relating to the breeding biology of each species was included. Species breeding in woodland, (where martens are likely to be most numerous) were given a score of 3, those breeding in woodland edge or scrubland habitat a score of 2, and those breeding on open moorland or sea cliffs a score of 1.

5. The scores from 3 and 4 above were then multiplied together to give an overall score and this in turn was ranked.

6. Birds were then given a green amber or red code. Birds in the green list have an overall score of 1, birds in the amber list have an overall score of 2-3, while birds in the red list have an overall score of 4-15. The results are shown in Table 3 below.

Table 3. Bird Species of some conservation status recorded on Mull

Species	BOCC	UK BAP	EU Directive	Conservation Score	Habitat Score	Total score
Wood Warbler *Phylloscopus sibilatrix*	3	2	0	5	3	15
Grasshopper Warbler *Locustella naevia*	3	2	0	5	2	10
Yellowhammer *Emberiza citrinella*	3	2	0	5	2	10
Starling *Sturnus vulgaris*	3	2	0	5	2	10
Tree Pipit *Anthus trivialis*	3	2	0	5	2	10
Linnet *Carduelis cannabina*	3	2	0	5	2	10
Corncrake *Crex crex*	3	2	1	6	1	6
Herring Gull *Larus argentatus*	3	2	1	6	1	6
Lapwing *Vanellus vanellus*	3	2	1	6	1	6
Cuckoo *Cuculus canorus* *	3	2	0	5	1	5
Reed Bunting *Emberiza schoeniclus*	0	2	0	2	2	4
Hen Harrier Circus cyaneus	3	0	1	4	1	4
Dunlin *Calidris alpina*	3	0	1	4	1	4
Red-breasted Merganser *Mergus serrator*	0	0	1	1	3	3
Goosander *Mergus merganser*	0	0	1	1	3	3
Red Grouse *Lagopus lagopus*	0	2	0	2	1	2
Merlin *Falco columbarius*	0	0	1	1	2	2
Tufted Duck *Aythya fuligula*	0	0	1	1	1	1
Teal *Anas crecca*	0	0	1	1	1	1
Short-eared Owl *Asio flammeus*	0	0	1	1	1	1
Shelduck *Tadorna tadorna*	0	0	1	1	1	1
Ringed Plover *Charadrius hiaticula*	0	0	1	1	1	1
Pochard *Aythya ferina*	0	0	1	1	1	1
Peregrine *Falco peregrinus*	0	0	1	1	1	1
Lesser Black-backed Gull *Larus fuscus*	0	0	1	1	1	1
Great Black-backed Gull *Larus marinus*	0	0	1	1	1	1
Eider *Somateria mollissima*	0	0	1	1	1	1
Common Tern *Sterna hirundo*	0	0	1	1	1	1
Common Gull *Larus canus*	0	0	1	1	1	1
Arctic Tern *Sterna paradisaea*	0	0	1	1	1	1
Red-throated Diver *Gavia stellata*	0	0	1	1	1	1
Snipe *Gallinago gallinago*	0	0	1	1	1	1
Golden Plover *Pluvialis apricaria*	0	0	1	1	1	1
Fulmar *Fulmarus glacialis*	0	0	1	1	1	1

The species list in Table 3 has been restricted to birds known to breed on Mull because the primary mechanism for marten predation is likely to be the consumption of eggs and young of nesting birds (BenDavid *et al* 1997). The weighting towards birds that breed in woodland or woodland edge reflects the overall habitat preference of martens, but they are known to occur in areas of boulder scree and in urban fringe habitats (Balastrieri *et al.* 2010; Birks *et al.* 2005) and may extend onto more open moorland if there are patches of woodland available nearby. Mixed conifer plantation and moorland is a common habitat mosaic on Mull (CEH 2000), so impacts on moorland nesting species cannot be wholly discounted. It is also the case that foxes are absent from the island so martens may be able to spread into habitat types that they are excluded from in other situations. Nevertheless, pine martens are most likely to impact on woodland or woodland fringe species and are less likely to impact moorland or cliff nesting birds.

The bird species featuring in Table 3 is therefore made up of a suite of species that utilise a range of habitats, ranging from woodland, coastal areas, moorland and agricultural habitats. Martens are able to hunt in a range of these (Balestrieri *et al.,* 2010), move large distances (Balharry 1993; Balharry *et al.,* 1996; Caryl, 2008) and are likely to encounter a mosaic of different habitat types frequently. As a result, birds that frequent agricultural habitats, such as lapwings and corn crakes, and traditionally moorland species such as hen harriers and short eared owls have been included in the list. It should also be noted however that martens themselves might be prey for larger raptors such as eagles especially when hunting in open moorland habitat. Indeed, in June 2012, a marten carcass was discovered on Mull that may have been the result of eagle predation (D. Sexton pers. comm.). However, such complex multi-trophic interactions are hard to predict, and so for completeness a range of moorland species has been included.

Inclusion of such a range of species is necessary as moorland species nest in or adjacent to forestry habitats (Fielding *et al.,* 2009) and martens, as well as other mustelids, have been identified as important predators of hen harriers (Fielding *et al.,* 2011). On the Isle of Skye, where martens have also recently colonised, hen harrier nests are being closely monitored to look at the species responsible for predation. To date all predation has been attributed to foxes (Fielding *et al.,* 2011) rather than martens on the island. However, it may be that, on Skye, marten predation may not, as yet, be occurring because the species has not yet colonised areas where hen harriers breed, or indeed are being precluded from doing so by foxes as the two species compete strongly (Lindstrom *et al.,* 1995). It should also be noted that foxes are not present on Mull. So it is difficult to predict how martens will interact with native raptor species such as hen harriers, and draw parallels from Skye.

A number of waterfowl species have been included in the list above as martens are also able to swim out to small islets in freshwater systems to prey on species such as red throated divers (M. Wilson pers. comm.). A more significant impact is likely to be predation or site competition with hole-nesting waterfowl such as goosander and red-breasted merganser. Seabirds have also been included, as they are colonial nesters and if martens ever reach offshore islet nesting sites they could have serious impacts.

Many of the species listed currently occur on the Scottish mainland in areas where martens also occur. Thus it could be argued that they are able to withstand a certain level of predation. The presence of martens on Mull, together with other introduced species such as mink may cause local extinctions and when put into the context of the conservation status of the species concerned at a regional or national level, the long-term conservation of these sub-populations becomes even more important.

A number of species not listed above are vulnerable to predation and competition for nest sites with martens. These include a range of hole nesting birds such as jackdaws (Corvus monedula) and owls (Johnsson, 1994; Overskaug *et al.,* 1999).

3.1.2 Indirect impacts

It is possible that martens could have an impact at an ecosystem level over a long period through a number of less apparent, indirect means. These are elaborated upon below. Indirect impacts discussed in this section are purely hypothetical as it is difficult to predict the longer term less apparent 'knock-on' impacts martens may have on other species.

i.) *Competition*

Martens feed on a wide variety of prey, but where possible, show a preference for microtine rodents such as voles (Helldin, 2000; Putman, 2000). These are also the primary food source, when available, for species such as hen harriers and short-eared owls. As vole populations at northern latitudes cycle and crash with vole predator populations following, through reduced reproduction (Norrdahl and Korpimäki 1995), during periods of low vole density, competition may result between birds of prey and martens, although this phenomenon would apply on the mainland too, where martens, short-eared owls and hen harriers exist in the same area. Also, as generalist predators, martens may fare better than hen harriers and short-eared owls, as they can sustain themselves on alternative food sources including plant resources (Clevenger, 1996). In combination with potential predation, impacts may be far-reaching, subtle and difficult to predict.

They may also compete for tree holes for denning with hole-nesting bird species such as jackdaws and owls as described above, and again in combination with predation the impacts may be disproportionately large.

ii.) Changes in species composition

Martens may selectively prey upon some species over others, causing long term changes in species assemblages. This was seen in the Hebrides where the presence of invasive predators such as hedgehogs (Erinaceinae europaeus) and the later arrival of mink, altered the species composition of the ground nesting bird community (Angus, 1992). Some species that are highly vulnerable to predation due to their nesting habits, such as terns, showed large decreases in populations relative to other species (Roy, 2009).

iii.) Wider trophic effects

Martens, together with genets (*Genetta genetta*), were introduced to the Balearic Islands several centuries ago. Here they have caused the extinction of native reptiles and birds through predation and competition; species which were important pollinators of native plants. Native plant communities are now highly altered as a result, with wind and insect-pollinated and dispersed species dominating the ecosystem (Traveset,1995; Traveset, 2002). Although the ecosystems of Mull are very similar to the mainland habitats of the west coast of Scotland, where martens are already present, it is hard to predict what long term changes may occur on Mull if martens spread and establish.

3.2 Other vertebrates

The only other group of vertebrate species vulnerable to marten predation is reptiles and amphibians (Traveset, 1995). The reptile species recorded on Mull are adder (Vipera berus), common lizard (Zootoca vivipara) and slow worm (Anguis fragilis), and their recorded distributions are shown below (http://data.nbn.org.uk) (Figure 5). The distribution maps shown however are probably a reflection of under-recording rather than accurate species distributions. These reptile species are common and widespread on the mainland where

martens exist already, and any additional effect from martens seems unlikely. However, any populations found on Mull that are already at the margins of their range, and affected by a range of threats, such as potential predation by other predators such as feral or domestic cats and mink, habitat loss and the burning of moorland, may show range contraction through additional marten predation.

Common frogs and toads are also present, together with newts, and although there is little information on the species, it is highly likely that they are palmate newts (Lissotriton helveticus) rather than the great crested newt (Triturus cristatus), a European Protected Species (Frog Life pers. comm.). All these species may be vulnerable to predation by mustelids, and may be particularly at risk when they are at high densities, for example as some frogs are during the mating season. Some mustelid species specialise on these species during such periods (Lode, 2000), but the impact of (resident) otters may be expected to be far higher than that of (newly-arrived) pine martens.

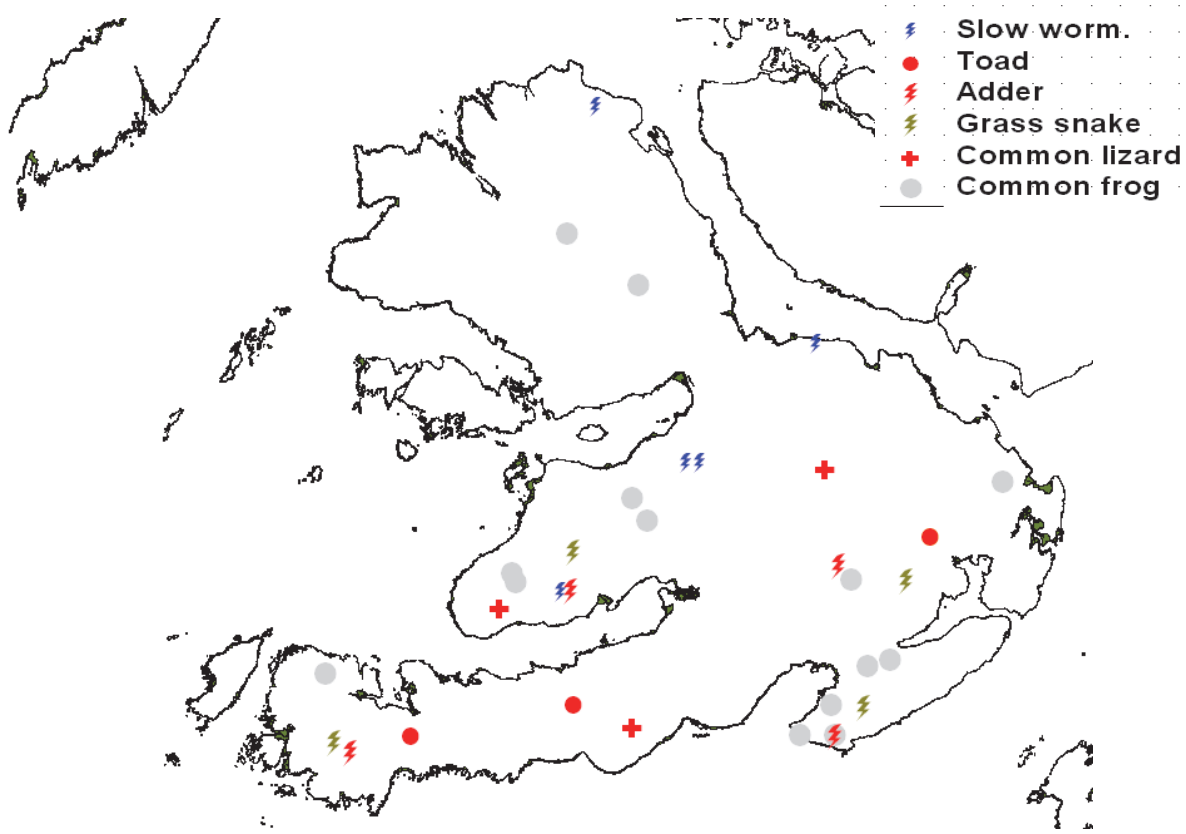

Figure 5. The distribution of reptiles and amphibians on Mull (Data sourced from the NBN gateway). *[Note that the grass snake (Natrix natrix) records are either misidentifications, escapees or introductions. The species does not naturally occur on Mull (or elsewhere in Scotland, except perhaps the extreme south).]*

3.3 Economic impacts

3.3.1 Impacts on game and farming

Martens are highly predatory on game birds, especially grouse species, pheasants and partridges. Pheasants *Phasianus colchicus* are both present and hunted on Mull, and predation by martens could result in conflict. This may be mitigated to some extent by well-designed fences, something that has worked well where game birds such as pheasants are

reared for release, (Balharry and MacDonald, 1999). Therefore estate owners will be important stakeholders in deciding how best to manage martens on Mull.

Many residents on Mull rear their own poultry, on which martens could prey. Again, well-designed, purpose-built fences could reduce the problem, and some light-activated fences and doors currently deployed on the Isle of Skye specifically to deter martens since their arrival seem to be proving effective at keeping them out. It should be noted that martens have mainly been preying on poultry in the vicinity of those households feeding them at bird tables (R. Cottis pers. comm.).

3.3.2 Positive and negative impacts to tourism

As discussed above martens *could* impact negatively on Mull's ecology, especially if they reach the lesser islands, and they may have a number of direct economic impacts on the game bird industry and on poultry raised by crofters. Martens may also have longer term indirect impacts that may be hard to quantify. For example, should they impact on harriers or other raptors, or on seabird colonies on offshore islands, the eco-tourism industry may be affected through reductions in visitor numbers. Though not recorded frequently, martens are potential predators of seabirds, and this has been seen with a similar species the American marten *Martes americana* in the Queen Charlotte Islands, British Columbia (Simberloff, 2009).

Martens however, are a tourist attraction in their own right, and by regular baiting at bird tables, can easily be attracted to gardens (Plate 2), and could provide an added attraction to the many bed and breakfasts and hotels on Mull. Thus, they could have a positive economic benefit to the island, if tourists were to visit to see pine martens. Marten watching is an additional source of income on some estates in the Highlands, such as the Rothiemurchus and Aigas estates and numerous B&Bs in Speyside advertise marten watching in the local press.

Plate 2. Pine martens being fed in a garden on Skye (photo A. Horner)

4. COMPARISONS WITH OTHER ISLANDS

4.1 Comparisons with Skye

Pine martens have been present on Skye since shortly after the completion of the road bridge in 1995 (Table 4), and have spread approximately 40 km westwards towards Carbost, from the bridge in 15 years. They are present in all habitat types, and their population is speculatively estimated at less than 50 individuals (R. Cottis pers. comm.). They are not reported as having any serious impacts on game bird or wildlife populations as yet. There are however some reports of poultry being taken, especially where martens have been attracted into gardens and bird feeders by residents. Light-activated hen coop doors and well-constructed fences seem to have reduced the problem. Occupancy of roof spaces and buildings, together with breeding events, have been recorded on Skye. In neighbouring Lochalsh on the mainland, martens have been found denning in boulder piles and in roof spaces. It should also be noted that unlike on Mull, martens have constant access to Skye from the mainland via the bridge, and are regularly seen on the bridge and as road traffic casualties on roads either side of the bridge.

4.2 Martens on the Balearic Islands

In the Balearic Islands, martens have been present for several centuries, though it is unknown how long the species has been there. Here they are believed to have altered the ecosystem by predating on and out-competing native pollinators and seed dispersers; (generally reptiles) which are now only found on marten-free islands within the archipelago (Traveset, 1995; 2002).

Research has shown that on the Balearic islands where martens are present, certain reptile species such as *Podarcis lilfordi* are extinct. These species are important for the dispersal of native plants such as *Cneorum tricoccon*, a role fulfilled on islands where martens are not present and the smaller reptiles are still extant. Although martens and to some extent genets (also an introduction from Roman times) fulfil some of the seed dispersal roles, the distribution of the plants these invasive mammals disperse is influenced by their habitat requirements and as such is markedly different to the distribution of plants on islands where they are reptile-dispersed.

Although the long-term impacts of pine martens on Mull, together with the impacts of mink are difficult to predict, species composition and distribution should be monitored, and compared to any baseline data that may exist prior to the invasion of these two species.

Table 4. The documented spread of pine martens on Skye (provided by R. Cottis)

Pine marten Activity - Skye	Date	Comments
Martens arrive on Skye at Kyleakin	October 1995	Skye Bridge opened 16/10/95. 2 road casualties within two weeks.
Scats recorded in FCS Kinloch & Kyleakin Hills SAC	November 1996	FCS Kinloch & Kyleakin Hills SAC adjoins the bridge at Kyleakin. Scats confirmed to be marten by Bristol University
FCS Kinloch & Kyleakin Hills conifer felling	2005	House roofs invaded. Pine Martens recorded in the Sleat peninsula.
Broadford FCS conifer plantation	2000	Scats found

Skye Bridge	2000	Martens seen regularly
Ashaig – Breakish Torrin	2003	Martens seen regularly at Ashaig, one male casualty on A87. Followed by an attack on hens at Breakish. Martens seen at Torrin, probable expansion across Strathaird peninsula.
Skye Bridge	2004	Male road casualty suggesting a flow of martens from Lochalsh
Broadford FCS conifer plantation	2006	Anecdotally conifer felling accelerated spread with unconfirmed reports of martens heading north.
Harrapool - Broadford	December 2009	Martens in roof & neighbour lost 2 hens, marten seen.
Kylerhea	2000 & 2005	Scats & martens seen in village. Subsequently fed on bird tables then 12 hens killed in 2005.
Kylerhea	March 2011	Two marten kits found in old building being renovated, moved to Vets then SSPCA.
Carbost	March 2011	Marten seen in NG3831. Confirming spread north from Broadford.
Kyleakin	September 2011	Martens in roof, neighbours feeding 2 martens

5. MANAGEMENT OPTIONS

5.1 Lethal options

Management options can be divided into two main categories, lethal and non-lethal, followed by a range of sub-options appropriate to different long-term management strategies. To start with, a range of different lethal control options are presented below. We recognise that the means by which lethal control might be carried out within the terms of the Wildlife and Countryside Act would need further investigation.

5.1.1 Eradication

The Convention on Biological Diversity outlines the precautionary principle to the management of invasive species (UNEP, 1992). This is a hierarchical process of preferred options which are summarised as follows:

- Prevention of the species getting to a novel area.
- Rapid containment of the species once it has arrived.
- Eradication of the species as a finite management option.
- Long-term control, the least preferred of all options.

In the absence of prevention, eradication through the containment and removal of a small population of a potentially invasive species is the next best option in accordance with the precautionary principle as outlined above (Wittenberg and Cock, 2001). Martens at high density are relatively easy to trap (M. Wilson pers. comm.), and the species can be dispatched humanely and quickly using techniques described for mink and other mustelids, using air rifles or lethal injection (Roy *et al*., 2009). The species, though recovering, is still rare in the UK outside of Scotland, and stakeholder engagement with landowners, NGOs, public bodies and the public will be needed in association with any eventual management decision.

In conjunction with this, a public education campaign should be carried out to reduce the risk of deliberate or accidental reintroduction. The threat of deliberate reintroduction is always possible and needs to be mitigated in order to prevent the breaking of one of the “golden rules” of eradication (Bomford, 1995). These golden rules are essential criteria that must be applicable to any eradication if it is to be successful, and are now accepted as being the following:

- All individuals must be put at risk by the control technique.
- There must be sufficient commitment by stakeholders and funding agencies to see the eradication through to the end.
- There must be little or no risk of reinvasion.
- More animals need to be removed than are replaced by reproduction.
- Appropriate techniques need to be used for removal and monitoring.

Also the removal of the last few individuals of an elusive carnivore would be difficult, greatly adding to the expense of such an operation, something seen on other eradication projects (Bloomer and Bester, 1992).

5.1.2 Control of selected populations and individuals

The second option is recommended only where eradication is not an option due to funding or practical limitations. In this situation marten populations can only be managed indefinitely by the lethal control of individuals or small sub-populations. Individuals or sub-populations close to populations of native species of conservation concern could be selectively culled or

removed through non-lethal means (discussed later). This strategy is based around the conservation needs of species of conservation concern, rather than the ecological needs of the invasive species and management is focussed on predator removal in areas surrounding protected areas at sensitive times of the year, such as bird breeding seasons to prevent martens entering sensitive areas (Roy *et al*., 2009). If eradication of the species is not an option this strategy is only suggested as an emergency measure if martens were ever to colonise areas close to sensitive bird populations such as those on Iona, Staffa or the Treshnish isles, and would need to be combined with intensive monitoring programmes (discussed later).

Individuals within a carnivore population sometimes specialise, disproportionately preying upon a particular species, which may be of conservation or economic importance. Such individuals are known as rogues, and removal of rogues, once individuals are identified through effective monitoring programmes, can be an effective way of protecting a scarce resource (Alterio and Moller, 1997).

5.2 Non-lethal options

A range of non-lethal techniques has been studied since the 1950s in order to look at ways of managing carnivore species to mitigate human - wildlife conflicts through more publicly acceptable means. The most feasible of these are described below:

i.) Behavioural

A range of behavioural techniques exist in deterring and training carnivores from attacking prey species of conservation or economic importance. Perhaps the most appropriate of these is conditioned taste aversion, where dummy baits, such as poultry eggs, are laced with distasteful chemicals and presented to the predator. The chemicals cause short-term illness or discomfort, thereby training exposed individuals to avoid that particular prey item (Conover, 1990). There is some evidence that this can work on generalist predators such as foxes, and may work on martens (Massei *et al*., 2003). There is however little research done on martens in this context.

ii.) Exclusion

A number of studies have been carried out designing exclusion devices on martens, with a large proportion of the work being undertaken on refining the design of fences, which have proved to be effective (Balharry and MacDonald, 1999). This is a technique that could be used to exclude martens from enclosed, economically valuable prey, such as the young of game birds, or poultry, thus mitigating some of their economic impacts. Light-activated doors on poultry coops are said to have had some success on Skye (R. Cottis pers. comm.).

iii.) Translocation

Though often purported to be a publicly sensitive strategy, translocation, the removal of individuals to new areas where they should occur naturally, has limited success and has associated welfare concerns. Translocations of some marten species have already been carried out, with pine martens being reintroduced to forests in Galloway (Bright, 2001), and fishers *Martes pennanti* being introduced to forest tracts where they have been hunted out in America (Davis, 1983). However, carnivore populations are highly structured (Sandell, 1989), and can be disrupted by the introduction of new individuals, sometimes resulting in the death of translocated individuals (Massei *et al.,* 2008).

5.3 Monitoring

Data on the numbers and distribution of martens on Mull are scarce. Such data are needed to inform estimates of the cost, if not also to guide the decision, on the most appropriate management. However, data collection should not be undertaken at the expense of management measures that may be needed, as early intervention is always the most cost-effective option according to the precautionary principle (Wittenberg and Cock, 2001).

It is recommended that monitoring should be a key element of any management strategy and any information yielded can be used to understand how quickly the population is growing or reducing, thus allowing managers to allocate appropriate control efforts. If management results in the collection of animals or faeces, then an understanding of the diet will refine our understanding of their impact on other species. If monitoring is carried out alongside any management programmes, the effectiveness of the management programme can be continuously assessed and fine-tuned through a process of adaptive resource management, maximising its effectiveness (Walters, 1990). This technique has already been successfully applied to the Hebridean Mink Project (Roy, 2009) and is recommended by invasive species practitioners involved in practical management (Roy, 2008).

A number of different monitoring strategies can be deployed, preferably in combination, to gain a wider understanding of the marten population and a number of different techniques are available for monitoring carnivore populations (Wilson and Delahay, 2001). The most feasible options have been listed below, together with examples of techniques that could be used to implement them.

i) Direct active techniques

Though labour-intensive and expensive, this strategy will yield the most information about the ecology of martens on Mull. Direct, active surveillance techniques include catching animals, collaring them and carrying out radio-tracking studies. This could help find den sites and sub-populations, and help to focus management efforts. Thus, the marten population on Mull would, for example, make a good topic of study for a PhD student, which could also be a low cost option. However, again, this should not be done at the expense of management at an early stage, and perhaps could run alongside any management programme.

ii) Direct passive techniques

By placing equipment in the field, such as camera traps, animals can be passively photographed, recording their movements across the landscape. The technique is already well-established for studying carnivores (Carbone *et al*., 2001), and data analysis techniques are well-developed especially for marten species (Zielinski and Stauffer, 1996; Foresman and Pearson 1998; Porter *et al*., 2005). Similar protocols can be applied for collecting fur from hair tubes, which can then be subjected to DNA analysis to identify individuals (Lynch *et al.,* 2006). Both techniques have their own respective merit. Camera trapping for example, requires little ongoing maintenance and input, while capturing DNA through hair trapping, though cheap to run, may require expensive laboratory sample testing.

iii) Indirect active techniques

This strategy involves looking for indirect evidence of martens, such as scats, yielding crude information on distribution and indirect indices of population densities (Birks *et al.,* 2004). Though labour intensive, the process can be made more efficient using trained searching dogs to find scats (Fukuhara *et al*., 2010). The collection of scats has the additional benefit of providing dietary information, and if fresh, individuals can be identified from DNA, giving more reliable population estimates (Rosellini *et al.,* 2008).

iv) Indirect passive techniques

Indirect passive techniques include collating sighting information from tourists and locals. Although the least labour intensive, this technique can yield a large quantity of low quality information, and if sighting information is weighted appropriately, information can be graded to refine results (Solow, 1993). An example of data collected in this way includes the collection of sighting data from the general public through questionnaire surveys. It is recommended that this technique is carried out regardless of the outcomes on future decisions on marten management on Mull. A preliminary database of sightings and scat collection information has been established as a result of this project and could be maintained with little effort.

6. DISCUSSION

Based on the available evidence, martens are not native to Mull and have never occurred there naturally. A population has recently been discovered in and around the port of Craignure. On the balance of evidence and discussion with local stakeholders it is assumed that individuals have arrived on the island having stowed away on timber-carrying boats.

The current population is assumed to be small, subjectively estimated at less than 20 individuals. There have been a number of sightings approximately on the east and south eastern side of the island, mainly in and around Craignure. These have included a number of sightings, the collection of faecal material, a breeding event in 2010, and a carcass found in 2012. Using sighting records and a modified extinction model it is estimated that individuals arrived on Mull in approximately 2004.

The habitat mosaic available to martens on Mull is very similar to the West Coast of Scotland, and the Isle of Skye both of which support marten populations. In addition to the moor and woodland available, forestry plantations (shown elsewhere to favour martens) are in abundance. Marten populations are typically restricted by a shortage of den sides and through competition with or direct predation from foxes. On Mull there is an abundance of denning habitat available, and there are no foxes. Food availability on Mull is unlikely to be an issue, with a range of vertebrate prey species; especially voles, birds, fruit, food put out for birds in gardens and domestic poultry. As a result, it is likely that martens could readily establish on Mull.

Martens have the potential to impact on a range of bird species. A number of birds of conservation concern, UK BAP red list species, and species listed in Annex 1 of the EU birds directive breed on Mull. Martens could prey on many of them in a range of different habitat types. Of particular note are ground nesting species such as corn crakes, woodland species such as wood warblers, and some waterbirds such as divers. Also listed are species on offshore islands near to Mull, such as Treshnish, where nationally important seabird colonies are found. If martens ever colonised these areas they would have a serious impact. Some species not listed for the purposes of this report may also be impacted, such as hole nesting species including woodpeckers (Dendrocopos sp) and tawny owls (Strix aluco). Predation by martens together with other introduced predators such as mink, may decimate the island's populations of some species. As well as impacting through predation, martens can also compete for small rodent prey with species such as hen harriers and short eared owls. The outcomes of interactions between native and introduced predators are hard to predict.

The long-term impacts of martens on the ecosystems on Mull are hard to predict, as they are subtle, complex and there are few comparators. In Skye, where martens have established in the last 15 years, the impacts caused by martens are yet to be seen on the species highlighted in Mull such as hen harriers. It should be noted however that Skye has a native fox population which may have restricted the spread of martens. In the Balearic Archipelago where the species has been present for several centuries, martens together with genets have caused the extinction of several reptile species, which on predator-free islands are responsible for the dispersal of several native plant species. As a consequence, patterns of plant distribution have been altered on those islands were invasive predators are present.

Economically martens are important predators of domestic poultry and game birds. They may therefore have an economic impact on the island. This may be counterbalanced by the positive impacts they may have in terms of tourism.

There are broadly three management options available – the removal of the current population to achieve eradication; localised management to reduce damage or limit spread; or a non-intervention approach. A range of different methods are available in each case.

There is a range of options can be used to manage the population of martens on Mull. They are easily trapped and could be humanely dispatched using techniques available for other mustelids species. The species could be eradicated, and should be if it ever reached offshore islands such as Iona or Treshnish. This would need to be carried out in conjunction with a range of public education and stakeholder engagement campaigns. Where eradication is not an option, the species could be managed indefinitely in the interim through long-term trapping and the removal of martens from areas close to sites of conservation interest to prevent the species from entering them.

A range of non-lethal management options are also available such as conditioned taste aversion, exclusion from sensitive areas through techniques such as fencing and translocation. Non-lethal options have mixed results, and translocation often has hidden welfare consequences which can reduce its effectiveness or acceptability.

A key principle of non-native species management is that early intervention is most often the most effective and cost-effective decision. Alongside whatever management is chosen the active monitoring of the population is recommended, through focussed study, the use of remote techniques such as camera trapping, scat surveys and the ongoing collation of sighting records. This will provide important information as a preliminary baseline, as well as during and after any management operations. Information yielded will be of great value as it could feed into management options and decision-making through a process of adaptive management.

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8. ANNEXES

8.1 Annex 1

An advert placed in "Round and About Mull", a local newspaper.

Pine Martens on Mull – we need your help

The pine Marten and is recently believed to have come to Mull and Iona. It can be identified by its bushy tail chocolate brown in colour with a cream/yellow throat patch. It is the size of a small cat (up to 20 cm high) and weighs up to 2 kg. We need your help in understanding the ecology of this species on the islands and where exactly the main populations are. Please help us by answering the following questions:

1. Have you seen one of these on Mull or Iona?
2. Have you mysteriously lost poultry recently to an unknown animal?
3. Have you had one of these animals living in your loft or shed?
4. Does this animal visit your garden?
5. Have you ever found one of these animals dead one the road?

If you can answer yes to any of these questions, please send an email to

Dr Sugoto Roy

Email address: pinemartensonmull@hotmail.co.uk

or ring 07824 865157

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Leachkin Road, Inverness IV3 8NW
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