Appendix 3.1a Letter sent with questionnaires.

Royal Holloway
University of London

- **School of Biological Sciences**
- **Professor J R Bowyer**
  Head of School
- Division of Biology
  Royal Holloway
  University of London
  Egham
  Surrey TW20 0EX

Dear Sir or Madam,

We are writing to ask if you would complete the enclosed short questionnaire please. It is part of research on the conservation of the pine marten being conducted on behalf of English Nature, the government's conservation agency and the People's Trust for Endangered Species. The questionnaire forms part of a consultative process and it is your opportunity to influence national policy regarding pine marten conservation. It will take only a few minutes of your time and all your answers will be confidential.

To help you complete the questionnaire we have also included an information sheet. This outlines why pine marten conservation is important in England and also gives a little background information about the pine marten itself. ***Could you please read this information sheet before completing the questionnaire.***

Please return the completed questionnaires in the enclosed pre-paid envelope.

Thank you very much indeed for your help.

Yours faithfully,

Paul Bright

Elisabeth Halliwell

Dr Paul Bright
Lecturer in Ecology

Dr Elisabeth Halliwell
Research Assistant

Appendix 3.1b Information sheet sent with questionnaires.

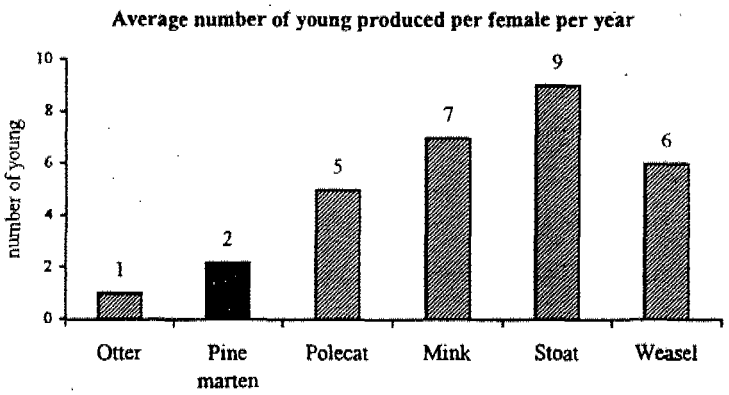
INFORMATION SHEET

PINE MARTEN CONSERVATION IN ENGLAND

English Nature, the government's conservation agency, in partnership with the People's Trust for Endangered Species has initiated a Species Recovery Programme for the pine marten in England. The questionniare accompanying this information sheet forms part of that programme.

1. *What is the pine marten?*

The pine marten is a cat-sized mammal related to the otter and the badger, that inhabits woodland. It is long lived, up to 12 years in the wild, but does not reach maturity until 3 years old and has small litters (3 kits is usual). Consequently pine martens breed slowly and are scarce even in favourable habitat. In these respects they are like otters, but quite unlike their other relatives the weasel, stoat, mink and polecat which breed faster and are more abundant.



2. *Why is pine marten conservation in England important?*

Pine martens used to be found throughout Britain. During the last century pine martens declined dramatically as a result of trapping, hunting and possibly the destruction of woodlands. At present there are no known populations remaining in England, although in Scotland the pine marten is gradually returning to parts of its former distribution. The pine marten has thus undergone a very extensive decline and is now probably the rarest mammal in England. It is protected by law.

ENGLISH NATURE

PEOPLE'S TRUST FOR ENDANGERED SPECIES

6. *Do they kill pheasants and chickens in pens?*

Yes they do. Like most animals they will take advantage of an easy meal. However, if pens are properly constructed, pheasants and chickens can be readily protected from pine martens. Furthermore, pine martens are scarce, even in favourable habitat, so they cause fewer problems compared to predators like foxes and stoats.

7. *If a pine marten was killed unintentionally in a trap, would a gamekeeper who set the trap be prosecuted?*

Probably not, provided there was evidence that due care had been taken to avoid killing pine martens. A new Code of Practice is being written to help gamekeepers in areas where reintroductions might take place. It is being developed in conjunction with the British Association for Shooting and Conservation and the Game Conservancy Trust and will include full advice on protection of game in release pens and avoidance of catching pine martens in Fenn traps.

8. *Would rarer birds and other rare animals be affected by pine martens?*

In general, scarce predators like the pine marten do not greatly affect the numbers of their prey. For instance when sparrowhawk numbers were reduced through pesticide poisoning earlier this century, small birds (the sparrowhawk's main prey) did not increase as might have been expected. This was because sparrowhawks had been eating 'surplus' birds that would otherwise have died, from starvation for example.

Nevertheless, for rare birds and other rare animals there may not be 'surplus' individuals to eat, perhaps because the species concerned are declining. A few individuals eaten might thus reduce populations of rare birds. However, rare birds occur at very low densities as do pine martens. So, pine martens will not usually encounter and eat rare birds. What's more, potential areas for pine marten reintroduction in England have been chosen to minimise overlap with the distribution of rare animals. Also, many of the birds of concern live in open country, which the pine marten, being a woodland animal, seldom visits. Finally, there are as many or more rare species present in parts of Scotland where pine martens already occur than in the potential release regions in England where pine martens are absent.

9. *If reintroductions to England were to go ahead, how would they be carried out?*

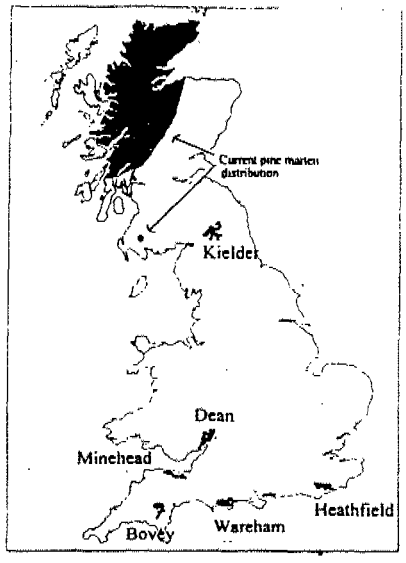
Pine martens would be removed from sites in Scotland where they have been breeding for many years. They would be held temporarily in an enclosure at a reintroduction site and then released. Pine martens would be intensively monitored for several years. In this way, the success of released pine martens and their effect on any rare species or game would be known. Reintroductions would only be carried out with the full support of local landowners.

10. What will happen next?

A booklet containing proposals for pine marten conservation in England will be published in early 1998. This will provide a foundation for consultation with landowners and all interested parties in regions to which pine martens *might* be reintroduced. It cannot be overemphasised that pine marten reintroductions would not be undertaken without further consultation and the support of landowners and gamekeepers. Nevertheless the pine marten, driven to extinction by trapping and hunting, is a high priority for wildlife conservation in England.

3. *How might pine marten conservation in England be promoted?*

It is certain that pine martens have not spread back to England in the last few decades. What's more pine martens released (reintroduced) in south-west Scotland by the Forestry Commission have spread only 7 miles in 15 years. It is thus clear that pine martens will not return to England of their own accord in the foreseeable future, especially as urban areas, roads and lack of woodland in some parts of England are likely to greatly reduce their spread. To restore the pine marten to England animals would need to be reintroduced. A number of potentially suitable regions for reintroductions have been identified based on the pine marten's habitat requirements. The acceptability of pine marten reintroductions is currently being assessed *before* any decision about future conservation measures is made.



Location of potential release regions with current pine marten distribution also shown.

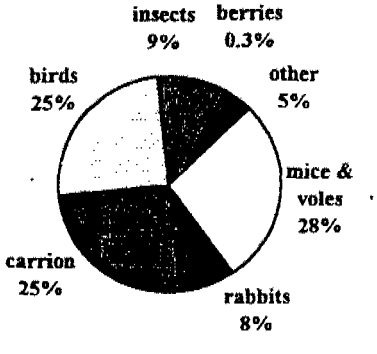
Possible pine marten reintroductions to England fully comply with international guidelines suggested by the world Conservation Union (IUCN). The ecology of the pine marten is well known. Martens are one of only three species for which detailed reintroduction trials have been attempted. The outcome of the reintroduction to south-west Scotland has also now been thoroughly investigated. A very substantial foundation of knowledge thus underpins any future proposals for pine marten reintroduction to England.

4. *How many pine martens are there in an area?*

Pine martens are solitary and defend very large territories. They are very thin on the ground even in prime habitat. In 2000 acres of prime habitat, there would be only 2 adult pine martens.

5. *What do they eat?*

Pine martens eat a wide variety of food. The greatest part of the diet is voles and mice. Pine martens will also eat rabbits and the remains of dead animals (carrion). Birds are eaten during the spring and summer. During the autumn pine martens will frequently gorge themselves on berries such as bilberry, rowan berries and cherries. They also eat insects such as beetles and grubs and pollen from bee and wasp nests.



Pine marten diet at a site in northern Scotland

Appendix 3.1c Questionnaire sent to farmers and members of the public.

QUESTIONNAIRE

PINE MARTEN CONSERVATION IN ENGLAND

The information sheet provided with this questionnaire gives some background information about the pine marten and its possible reintroduction to England. ***Could you please read the information sheet before answering the questions below.*** Your answers will influence English Nature policy on pine marten conservation in England.

Question 1. *Before you read the information sheet, had you heard of the pine marten?*

Yes ☐ No ☐

Question 2. *As explained in the information sheet we are currently assessing the acceptability of pine marten reintroductions. The ******** region has been identified as one of several* potentially *suitable regions based on the pine marten's habitat requirements. If successful, the reintroduction would lead to the re-establishment of pine martens in that region.*

*Are you in favour of the possible reintroduction of pine martens to the ******** region?*

Yes ☐ No ☐

If you answered 'yes' to Question 2, go to ***Question 3***. If you answered 'no' go to ***Question 5***.

Question 3. *If this reintroduction were to go ahead it might be necessary to raise additional money by setting up a fund to support pine marten conservation locally. The amount that people are willing to contribute towards this fund may influence the likelihood of the reintroduction going ahead. As you are in favour of a pine marten reintroduction to the ******** region, what is the maximum you would be prepared to contribute as a one-off payment to the fund?*

£0☐ £1☐ £2☐ £5☐ £10☐ £15☐ £20☐ £25☐ £30☐ £50☐ £100☐

Question 4. *What is the single most important reason why you are in favour of the pine marten reintroduction?*

Now go to ***Question 7***

Question 5. *If a fund were set up to* prevent *pine marten reintroduction to the ******** region, what is the maximum you would be prepared to contribute as a one-off payment to the fund?*

£0☐ £1☐ £2☐ £5☐ £10☐ £15☐ £20☐ £25☐ £30☐ £50☐ £100☐

Question 6. *What is the single most important reason why you are against the pine marten reintroduction?*

*Question 7. A number of other regions have also been identified as potentially suitable for pine marten reintroductions. Would you be more or less in favour of the reintroduction if it were to be in an area other than the ******** region?*

More in favour ☐ No difference ☐ Less in favour ☐

We also need to determine some information about yourself which will only be used for this study in which all replies are anonymous and confidential.

Question 8. Are you a member of the Game Conservancy Trust or British Association for Shooting and Conservation? Yes ☐ No ☐

Question 9. Are you a member of any other conservation bodies such as RSPB, WWF, local wildlife trusts etc? ☐ Yes ☐ No

Question 10. Do you walk or cycle regularly in the countryside? Yes ☐ No ☐

Question 11. Do you take part in pheasant, duck or rough shooting? Yes ☐ No ☐

Question 12. Do you shoot/trap animals such as foxes or deer, for the purposes of control?

Yes ☐ No ☐

Question 13. Do you keep any free range birds such as chickens or ducks?

Yes ☐ No ☐

Question 14. What is your occupation?

Question 15. Would you please give an indication of your household income?

less than £10,000 ☐ £10,000 -£19,900 ☐ £20,000 -£29,900 ☐ £30,000 -£39,900 ☐ £40,000+ ☐

Question 16. What is your age?

20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60+ ☐

Question 17. Are you Male ☐ or Female ☐

Thank you very much for completing this questionnaire. Could you now please return it in the enclosed pre-paid envelope to:-

Freepost
(Lon 82)
London
SW8 4YY

Appendix 3.1d Questionnaire sent to gamekeepers.

QUESTIONNAIRE

PINE MARTEN CONSERVATION IN ENGLAND

The information sheet provided with this questionnaire gives some background information about the pine marten and its possible reintroduction to England. ***Could you please read the information sheet before answering the questions below.*** Your answers will influence English Nature policy on pine marten conservation in England.

Question 1. *Before reading the information sheet how much did you know about pine martens?*

Nothing ☐ If you have not previously heard of the pine marten **please go to Q. 2**

A little ☐

Much ☐

Question 1a. *Have you previously worked in an area where pine martens were present?*

Yes ☐ Please write the name of the county where you encountered them.

.....

No ☐

Question 2. *As explained in the information sheet we are currently assessing the acceptability of pine marten reintroductions. The ****** region has been identified as one of several* potentially *suitable regions based on the pine marten's habitat requirements. If successful, the reintroduction would lead to the re-establishment of pine martens in that region.*

*Are you in favour of the possible reintroduction of pine martens to the ****** region?*

Yes ☐ If you are in favour of this possible pine marten reintroduction, go to ***Question 3.***

No ☐ If you are not in favour of this possible pine marten reintroduction, go to ***Question 4.***

Question 3. *Please indicate what are the three most important reasons why you would be in favour of pine marten reintroduction to the ..... region?*

1. Most important .....
2. Second most important .....
3. Third most important .....

Now go to ***Question 5***

Question 4. *Please indicate what are the three most important reasons why you would be against pine marten reintroduction to the ..... region?*

1. Most important .....
2. Second most important .....
3. Third most important .....

Question 5. *A number of other regions have also been identified as potentially suitable for pine marten reintroductions. Would you be more or less in favour of the reintroduction if it were to be in an area other than the ..... region?*

More in favour ☐ No difference ☐ Less in favour ☐

Background Information

We would also like to determine a little more information about yourself which will only be used for this study in which all replies are anonymous and confidential.

Question 6. *Please indicate if you are a member of any of the organisations listed below.*

Tick '✓' appropriate box(es)

- ☐ British Field Sports Society
- ☐ County Wildlife Trust
- ☐ Game Conservancy Trust
- ☐ Other .....
- ☐ National Trust
- ☐ Royal Society for the Protection of Birds
- ☐ Worldwide Fund for Nature (WWF)

Question 7. *Please indicate the one type of keeper which best describes yourself.*

- ☐ Single handed keeper
- ☐ Head keeper
- ☐ Under keeper
- ☐ Beat keeper
- ☐ Amateur keeper
- ☐ Other .....

Question 8. *Please indicate the approximate number of gamebirds (pheasant, duck and partridge) that are released on your ground each year.*

Number released .....

Question 9. *Please indicate which of the following categories includes your age?*

20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60+ ☐

Thank you very much for completing this questionnaire. If you have any further comments you wish to add please do so below.

Please now return this questionnaire in the enclosed pre-paid envelope to BASC.

Appendix 3.2 Characteristics of respondents in favour and against pine marten reintroductions, % of respondents in each category.

Region		n	Know	Cons_mem	Game_mem	Chickens	Shoot_con	Shoot_phe	Walk	Male
Public										
Bovey	for	66	90.9	33.3	3.0	10.6	3.0	4.6	92.4	53.0
	against	9	88.9	11.0	0.0	0.0	0.0	0.0	100.0	50.0
Dean	for	56	76.8	25.0	1.8	7.0	5.4	3.6	85.7	61.8
	against	5	80.0	40.0	0.0	20.0	0.0	0.0	100.0	80.0
Heathfield	for	58	70.7	36.2	1.7	10.5	1.7	5.2	79.3	44.8
	against	2	50.0	0.0	50.0	0.0	50.0	50.0	50.0	100.0
Kielder	for	60	91.7	24.1	5.1	8.5	6.8	15.5	88.3	60.0
	against	8	100.0	14.3	28.6	37.5	37.5	37.5	100.0	62.5
Minehead	for	67	74.6	31.3	4.5	4.5	7.5	7.5	92.4	52.2
	against	12	75.0	58.3	0.0	8.3	8.3	16.7	91.7	50.0
Wareham	for	61	86.4	28.3	10.0	1.7	4.9	11.5	91.5	57.6
	against	6	100.0	33.3	33.3	16.7	33.3	33.3	100.0	50.0
Farmers										
Bovey	for	45	95.6	29.5	11.1	60.0	61.4	41.9	84.1	91.1
	against	26	96.0	15.4	4.0	65.4	69.2	34.6	92.3	66.7
Dean	for	34	88.2	39.4	20.6	41.2	44.1	36.4	69.7	85.3
	against	14	78.6	7.7	28.6	35.7	50.0	35.7	78.6	76.9
Heathfield	for	49	93.9	39.8	6.3	42.9	46.9	31.9	95.9	87.8
	against	26	92.3	32.0	38.5	50.0	73.1	73.1	100.0	84.0
Kielder	for	42	83.3	31.0	11.9	31.0	48.8	42.5	90.2	77.5
	against	28	85.7	23.1	19.2	65.4	44.4	38.5	88.9	84.0
Minehead	for	38	84.2	34.2	15.8	42.1	47.4	39.5	81.1	84.2
	against	27	70.4	16.0	25.9	46.2	61.5	38.5	76.9	96.0
Wareham	for	51	88.2	34.7	25.5	38.0	46.0	54.9	80.0	84.3
	against	22	71.4	27.3	27.3	45.5	45.5	59.1	95.5	81.8

Know=previously heard of pine martens
Cons_mem = member of conservation organisation
Game_mem = member of a game organisation
Shoot_con = shooting for the purpose of control
Shoot_phe = interest in shooting pheasants or ducks
Walk=walk in the countryside

Appendix 3.3a Reasons given by the general public and farmers for why they are in favour of pine marten reintroductions to their region.

Reason	Public n	%	Farmers n	%
Protect rare spp	100	27.2	69	26.6
Native spp	58	15.8	37	14.3
Balance of nature	32	8.7	20	7.7
Conservation	49	13.3	22	8.5
Diversity	40	10.9	28	10.8
See one	15	4.1	17	6.6
Children	7	1.9	3	1.2
Grey squirrels	1	0.3	0	0
Control rabbits etc	2	0.5	6	2.3
Other	12	3.3	3	1.2
No opinion	52	13.6	54	20.9

Appendix 3.3b Reasons given by the general public and farmers for why they are against pine marten reintroductions to their region.

Reason	Public n	%	Farmers n	%
Extra predator	8	19.0	50	35.0
Gamebirds	1	2.4	8	5.6
TB/Badgers	0	0	3	2.1
Song birds	8	19.0	13	9.1
Red squirrels	2	4.8	5	3.5
Compete e.g. owls	0	0	2	1.4
Balance of nature	0	0	2	1.4
Unsuitable area	5	11.9	13	9.1
Spread naturally	2	4.8	8	5.6
Too rare for removal	1	2.4	1	0.7
Money wasted	3	7.1	6	4.2
Other	5	11.9	11	8.4
No Opinion	7	16.7	21	14.7

Appendix 3.4a The three most important reasons why gamekeepers are in favour of pine marten reintroductions.

Reason	First N	%	Second n	%	Third n	%
Protect rare species	33	31.1	18	16.9	4	3.8
Native species	27	25.5	5	4.7	1	0.9
Balance of nature	5	4.7	6	5.7	3	2.8
Conservation	4	3.8	7	6.6	3	2.8
Diversity	3	2.8	4	3.8	0	0
Increased pine marten distribution	1	0.9	2	1.8	4	3.8
To see one	3	2.8	2	1.9	10	9.4
Children	0	0	4	3.8	1	0.9
Grey squirrels	0	0	2	1.9	5	4.7
Control rabbits	0	0	1	0.9	2	1.9
Suitable area	9	8.5	14	13.2	7	6.6
Minimal threat gamebirds	0	0	4	3.8	3	2.8
Co-operation of shooting with conservation	5	4.7	5	4.7	3	2.8
Tourism	0	0	1	0.9	8	7.5
Other	5	4.7	4	3.7	12	11.2
No opinion	11	10.4	27	25.5	40	37.7

Appendix 3.4b The three most important reasons why gamekeepers are against pine marten reintroductions.

Reason	First N	%	Second n	%	Third n	%
Extra predator	16	29.1	3	5.5	3	5.5
Gamebirds	18	32.7	7	12.7	1	1.8
Threat to poults	1	1.8	1	1.8	0	0
Extra problem	0	0	2	3.6	4	7.3
No control of nos.	2	3.6	4	7.3	2	3.6
Trapping may become illegal?	0	0	3	5.5	2	3.6
Fear of prosecution	0	0	1	1.8	2	3.6
Song birds	0	0	4	7.3	1	1.8
Red squirrels	1	1.8	1	1.8	1	1.8
Woodcock	1	1.8	0	0	0	0
Wildlife	4	7.3	2	3.6	2	3.6
Habitat unsuitable	6	10.9	5	9.1	3	5.5
Spread naturally	0	0	1	1.8	1	1.8
Colonisation	1	1.8	2	3.6	1	1.8
Disturbance to pms	0	0	3	5.5	4	7.3
Interference from conservationists/visitors	0	0	2	3.6	2	3.6
Money wasted	1	1.8	0	0	2	3.6
Don't know enough	0	0	0	0	3	5.5
Other	3	5.4	4	7.3	7	12.7
No opinion	1	1.8	10	18.2	14	25.5

4. Removal of pine martens from Scotland: site selection and impacts

4.1 Introduction

Bright & Harris (1994) showed that 30 to 40 pine martens would probably need to be released in an area to establish a new viable pine marten population. IUCN recommend that where sufficient stock are available wild caught animals are used for reintroductions (Anon 1995). These generally show higher survival and better adaptation to the new environments than captive bred animals (Bright & Morris 1994). Scotland would clearly be the most suitable source of pine martens for a reintroduction to England. Populations there have recovered a large part of their former distributional range and are continuing to expand (Velander 1983; Balharry *et al.* 1996).

However, marten populations are susceptible to overharvest as has been seen in Russia for *Martes martes* and *M. foina* (Grakov 1993) and in North America for *M. americana* (Hubert 1982). It is thus essential to assess the likely impact of removing pine marten from Scotland. A prerequisite for doing so would clearly be that existing populations were not damaged.

In this chapter we thus aim to identify and estimate the size of potential pine marten donor populations in Scotland. We then assess the impact of removing different proportions of adults and sub-adults from them using an age structured population model. This allows us to identify the maximum number of animals that could safely be removed from a given area and to develop a removal strategy that would safeguard existing populations.

4.2 Methods

4.2.1 Donor populations

Regions likely to contain suitable pine marten donor populations (PDPs) were identified on the basis of woodland cover, altitude and length of occupancy by breeding martens. The Countryside Information System GIS (Howard *et al.* 1994) was used for most of this work. Pine marten density is related to woodland cover (Balharry 1993a; Bright & Smithson 1997) and thus 1-km squares with less than 25% woodland cover and hence low pine marten density were excluded. Woodland cover (coniferous and deciduous) was determined within CIS from the Institute of Terrestrial Ecology's Land Cover Map which is derived from Landsat Thematic Mapper images (Barr *et al.* 1993; Howard *et al.* 1994). Squares greater than 300m above sea level were also excluded on the basis that they would have low productivity and thus a low prey base. This is shown, for example, by the spacing of sparrowhawk (*Accipiter nisus*) nests, which increases at higher altitude due to lower land productivity and hence prey availability (Newton 1986).

1-km squares were then selected where breeding pine martens had been established for at least 15 years, according to results of a survey in 1980-1982 (Velander 1983). Recent questionnaires (Balharry *et al.* 1996) and site visits (Halliwell 1997) have shown that pine martens are still

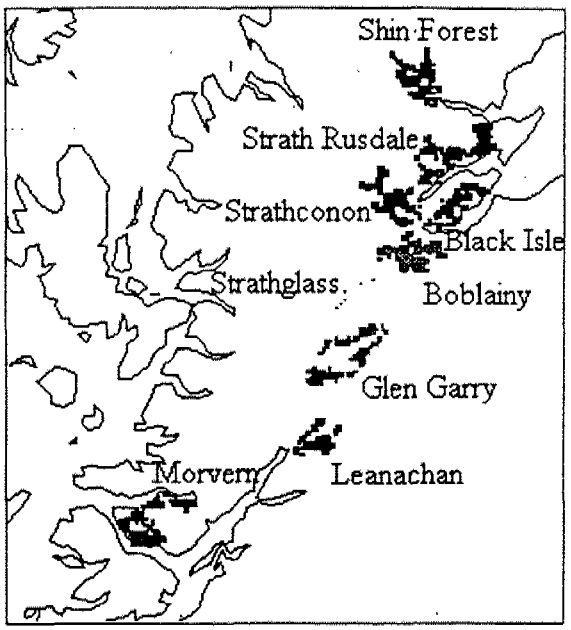


Fig. 4.1 Distribution of potential pine marten removal regions in northern Scotland.

present in these areas. Finally, regions that should encompass panmictic pine marten populations were identified by selecting groups of 1-km squares, wherein suitable squares were adjacent or separated by no more than 2km from another suitable 1-km squares. Two kilometers of less suitable (woodland cover <25%) habitat is unlikely to be sufficient to limit dispersal, or even within-territory, movements by pine martens (cf Balharry 1993a; Bright & Smithson 1997). A large proportion of the woodland within each of the selected regions is Forestry Commission (FC) owned, so the FC's Compartment Database was used to obtain information on woodland age and compartment areas for further analyses.

The probable density of pine martens in each region was assessed from indices of field vole *Mircotus agrestis* and song bird abundance, two of the dominant components of pine marten diet in Scotland (Balharry 1993a; Halliwell 1997). Field vole availability was indexed from the area of woodland aged 6-19 years in each region *ie* woodland suitable for field voles (Flowerdew & Trout 1995), but with sufficient tree cover for pine martens. The number of songbird pairs was estimated from bird densities measured in coniferous woodland of different ages (Moss, Taylor & Easterbee 1979). The vole and bird indices, expressed per km^2 of woodland, were standardised to z-scores and then summed to give a total for each region. We then assumed that the maximum of these summed prey indices would represent the maximum likely pine marten density $0.6/km^2$ (cf Balharry 1993a; Bright & Smithson 1997) The lowest of the summed indices we assumed to represent a low pine marten density of $0.25/km^2$. Pine marten density was assumed to scale linearly between these extremes for regions that had intermediate prey indices. Total pine marten population size was then calculated from the area of each region.

Two further indices of the suitability of regions were calculated. These were the length of edge habitat (sub-compartment area × 1.85 [perimeter:area ratio of sub-compartments in Galloway forest; P. Bright unpublished]) and woodland age diversity. The latter was calculated as an unbiased Simpson's index: $S = \sum_i(n^2\text{-}n)/(N^2\text{-}N))$ where n was the number of sub-compartments of age i and N total number of sub-compartments in a region). Sub-compartments were grouped

into six age categories: clear-cut & restock 0-8 years; pre-thicket 9-16; thicket 17-28; pole stage 29-44; middle aged 45-85; old forest >85 years; Catt & Staines 1987). These indices quantify increasing structural complexity of forests. High indices should correlate with a greater variety and more continuous seasonal availability of prey for pine martens.

4.2.2 Impact of removals

The effect of removing different numbers of pine martens from populations of different sizes was assessed using the age structured population model RAMAS/age v.2.0 (Ferson & Akçakaya 1993). The parameters used for the model were based on data from a sample of 6448 American martens harvested from a population in Ontario, Canada between 1972-1986 (Strickland & Douglas 1987). This population was subjected to only a low level of trapping and we assumed that the data can therefore provide reliable estimates of populations parameters for an unharvested population. These data were validated by comparison with those for a heavily harvested population from the Yukon, USA (n = 839; Archibald & Jessup 1984) and with the limited data available on pine martens (Corbet & Harris 1991). Juvenile (<1 year old) survival was estimated at $0.32/yr^{-1}$ and juveniles comprised 58% of the population. The mean survival rate of adults was $0.60/yr^{-1}$ from Strickland & Douglas (1987), but we revised this upwards to 0.75/yr-1 as harvesting, even at a low level, leads to a reduction in adult survival. We assumed a maximum longevity of 12 years and a sex ratio of 0.5. Strickland & Douglas (1987) showed that females do not produce young in their first year, that fecundity rates for two year olds are 2.58 and averaged 3.5 for older martens. However, data from Scotland (D. Balharry, pers. comm.) suggest that females do not breed until their third year and have litters of less than three young. Consequently we revised fecundity rates downwards to 2.0 and 3.0 respectively.

Coefficents of variation (CV) in vital rates between years were calculated from Strickland & Douglas (1987). Adult survival CV (18%) was calculated for individuals >1 year old and across eight age-classes where n>30 and over a 12 year period. Fecundity CV (12%) was calculated over a 12 year period. No data were available concerning variation in zero age class survival, which we assumed to be 30%. In general, these data represent best-case scenarios and higher between-year variation, in particular, might occur.

The model was run for 10 generations with 300 replications. Initial population sizes of 20 and 50 were used from which 10%, 15%, 20% and 25% of adult (>2 years olds) and, adult and sub-adult (2 year old) pine martens were removed. Populations were assumed to be increasing and density dependence was not explicitly modelled. Consequently our model does not account for any increase in population productivity that might result from reduced intra-specific competition following removal of pine martens. Conversely, it also does not incorporate reduced fecundity that could result from disruption of the pine marten's inflexible territorial system following removals (Balharry 1993b; D. Balharry pers. comm.).

4.3 Results

4.3.1 Pine marten donor populations

In total 9 potential pine marten donor regions were identified (Fig. 4.1) ranging in total size from 55km^2 (Strathglass and Leanachan) to 110km^2 (Shin Forest). Each had around 50% woodland cover (Table 4.1). The proportion of deciduous woodland was greatest in the Morvern region (43%) and only the Black Isle and Boblainy also had more than 10% deciduous woodland (Table 4.1). Mean compartment size was smallest for Morven, Glen Garry, Black Isle and Strathglass (8-10 ha) and greatest for Leanachan, Strath Rusdale and Strathconon (16-20 ha; Table 4.1). The total length of edge habitat ranged from an estimated 12 km at Boblainy and 19 km at Morvern to 56 km at Glen Garry and Strath Rusdale (Table 4.1).

The age diversity index of sub-compartments was greatest for Strath Rusdale and Glen Garry, and smallest for Boblainy and Shin forest (Table 4.1). Boblainy had a high proportion of pole stage and middle aged woodland and small areas of thicket and old forest, but little or no pre-thicket and clearcut/restock (Fig 4.2). The Black Isle region was composed of over 60% of one age class, middle aged woodland. In contrast, Strath Rusdale and Glen Garry had relatively even proportions of all age classes (Fig 4.2).

The proportion of field vole suitable woodland was nearly one third for Strath Rusdale whereas the Black Isle and Boblainy had less than 7% and 2% respectively (Table 4.1). Predicted song bird densities were greatest in the Boblainy, Strathglass and Leanachan regions and were lowest in the Strath Rusdale, Morvern and Shin regions (Table 4.1). When combined the vole/bird index predicted pine marten density to be greatest in the Leanachan, Strathglass and Strath Rusdale regions and least in the Black Isle, Morvern and Strathconon regions (Table 4.2). These densities amount to adult pine marten population sizes of between 11 (Black Isle) and 59 (Strath Rusdale; Table 4.2). Thus, if 10% of *adult* pine martens were removed between 4 and 6 martens would be available from the Boblainy, Glen Garry and Strath Rusdale regions, whereas only 1 could be removed from the Black Isle (Table 4.2).

4.3.2 Population consequences of removing pine martens

The age-structured population model showed that as the proportion of the population removed was increased from 10% to 25%, the probability of a population decline of at least 10% increased (Table 3). Thus for a population of 20 pine martens, removal of 3 adults (15%) gave a 21% chance of an immediate decline in population size. This increased to 43% when 20% of adults and sub-adults were removed. A similar effect was seen for a pine marten population of 50 such that when 15% of adults were removed there was a 26% chance of an immediate population decline and 37% chance when adults and sub-adults were removed (Table 4.3).

Two years after 15% of adults or adults and sub-adults pine martens were removed there was more than an 80% chance that populations of both 20 and 50 pine martens would have returned to their initial sizes. This probability increased to over 92% five years after the removals (Table 4.3). Even if 25% of a population (adults and sub-adults) was removed, there was a more than a 90% chance that the population would return to its initial size by five years after the removal (Table 4.3).

Table 4.1 Characteristics of potential pine marten donor regions in Scotland.

Site	Total area[a], km^2	Total woodland area[a], km^2 (%)	Deciduous woodland[a], % of total woodland	Area sub-compartment[b], km^2, mean±SE	Length edge habitat[b], km km^{-2}	Age diversity[b] (Simpson's index)	Vole index[b], % area suitable	Bird index[b], no. pairs per woodland area
Black Isle	64	29.72 (46.4)	10.63	0.10±0.006	24.52	4.20	6.7	387
Boblainy	90	42.62 (47.4)	16.02	0.14±0.012	12.12	2.74	1.6	436
Glen Garry	95	45.60 (48.0)	5.50	0.09±0.003	56.52	4.57	22.7	379
Leanachan	55	28.80 (52.4)	8.82	0.16±0.012	26.90	3.82	20.4	404
Morvern	94	48.96 (52.1)	42.65	0.08±0.007	7.44	4.05	16.4	370
Shin Forest	93	47.91 (51.6)	6.47	0.13±0.006	48.70	2.61	19.5	370
Strathconon	86	44.53 (52.8)	8.89	0.20±0.010	44.47	3.89	9.8	396
Strathglass	55	24.97 (45.4)	8.33	0.10±0.006	55.60	3.96	10.6	422
Strath Rusdale	110	54.45 (49.5)	8.76	0.17±0.008	39.54	5.32	30.9	367

[a]calculated from CIS data
[b]calculated from FC data

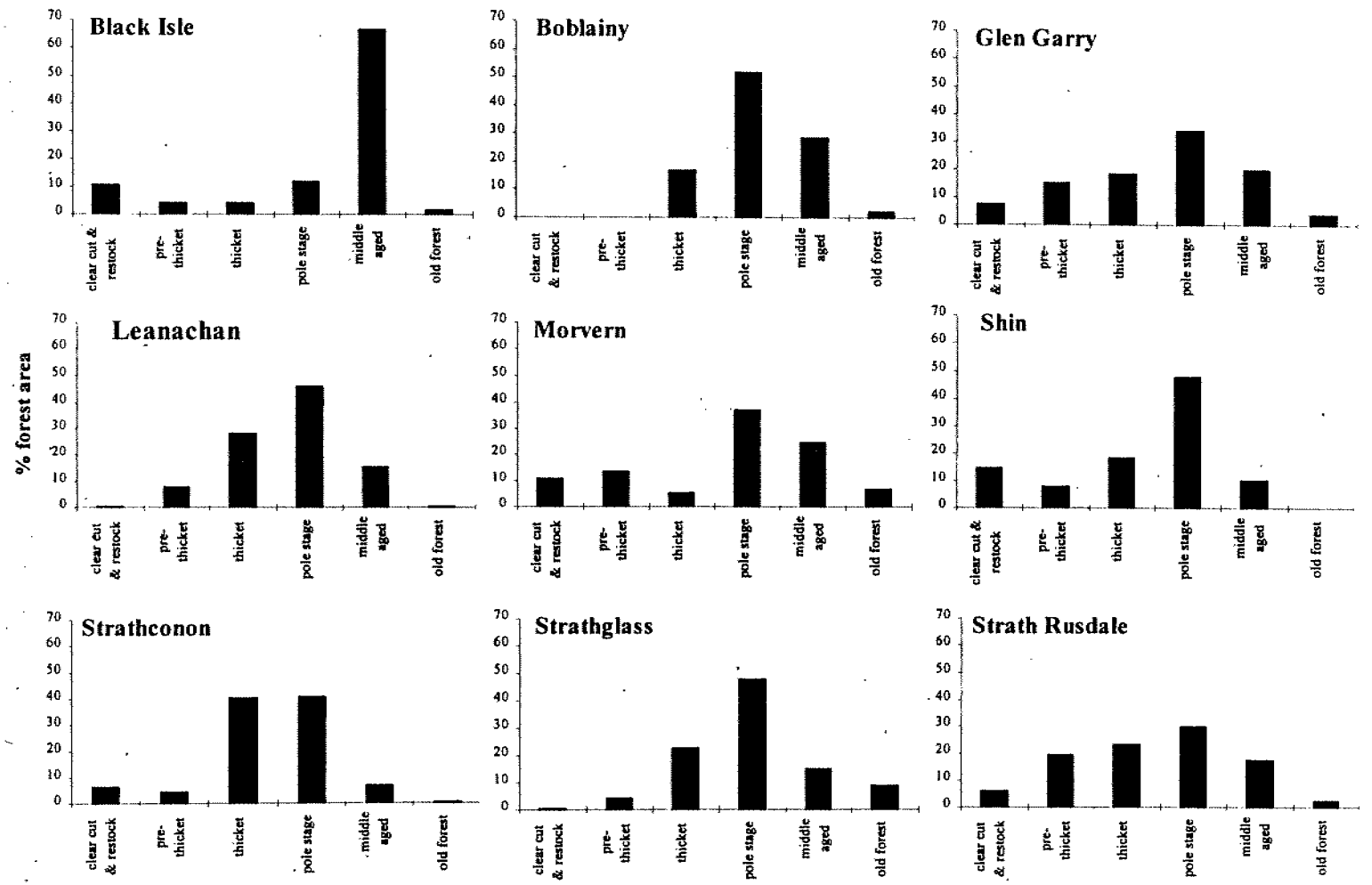


Fig 4.2 Age class structure of woodlands (% of woodland area) in each pine marten donor region. Data from the Forestry Commission Compartment Database. See text for details of age classes.

Table 4.2 Predicted size of pine marten populations in donor regions and the numbers of animals that would be available for reintroductions if various proportions of the populations were removed. The vole/bird prey index, on which estimation of population size was based, is also shown.

Site	Standardised vole/bird index[b]	Predicted adult pine marten density	Predicted no. adult pine martens in PDR	10% adults	15% adults	10% adults & sub-adults	15% adults & sub-adults	Rank
Black Isle	-1.17	0.18	11	1.1	1.7	2.0	3.0	9
Boblainy	0.27	0.46	41	4.1	6.2	7.2	10.8	3
Glen Garry	0.24	0.45	43	4.3	6.4	7.5	11.3	2
Leanachan	1.02	0.60	33	3.3	4.9	5.8	8.7	4
Morvern	-0.79	0.25	24	2.4	3.5	4.1	6.2	8
Shin Forest	-0.44	0.32	30	3.0	4.4	5.2	7.8	6
Strathconon	-0.49	0.31	27	2.7	4.0	4.7	7.0	7
Strathglass	0.80	0.56	31	3.1	4.6	5.4	8.1	5
Strath Rusdale	0.67	0.53	59	5.9	8.8	10.3	15.4	1

[b]calculated from FC data

Table 4.3. The effect of removing 10-25% of adults or adults and sub-adults from pine marten populations of 20 and 50 individuals. N, size of initial population; P_d, probability of a 10% decline in pine marten population size immediately after the removal; P_{2yr} and P_{5yr} probabilities of a population returning to its initial size 2 and 5 years respectively after the removal. The model was run with demographic and environmental stochasticity and no density dependence. See text for further details of parameters.

Adult population size	Cohort removed		% removed 10	15	20	25
20	Adults only	N	2	3	4	5
		P_d	0.173	0.213	0.270	0.373
		P_{2yr}	0.893	0.850	0.817	0.790
		P_{5yr}	0.913	0.923	0.933	0.92
	Adults, sub adults	N	3	5	6	8
		P_d	0.297	0.434	0.413	0.503
		P_{2yr}	0.890	0.873	0.823	0.720
		P_{5yr}	0.927	0.930	0.917	0.860
50	Adults only	N	5	7	10	12
		P_d	0.173	0.263	0.343	0.423
		P_{2yr}	0.920	0.883	0.877	0.757
		P_{5yr}	0.983	0.953	0.963	0.933
	Adults & sub adults	N	8	11	15	19
		P_d	0.330	0.367	0.560	0.517
		P_{2yr}	0.877	0.820	0.787	0.740
		P_{5yr}	0.953	0.947	0.920	0.933

4.4 Discussion

The nine potential pine marten donor populations identified are predicted to contain a total of nearly 300 adult (> 2 years old) pine martens. Although these predictions were based on indices of habitat quality and prey availability, they were scaled to match known densities in Strathglass and Strath Rusdale (Balharry 1993b; Halliwell 1997). It is thus likely that our estimates of density provide a reliable guide to population sizes. The lowest density estimate was for the Black Isle where pine martens are known to be present at least at moderate density (personal observations). Although not an island, the Black Isle is a peninsula connected to the 'mainland' by only an 8 km strip of land which might thus limited dispersal and produce artificially high numbers.

The proposed method for reintroducing pine martens would be to release a total of 30 animals in any one region over a two year period (see Chapter 6). This could be achieved with the smallest risk to donor populations by removing 10% of adults from half the regions over a two

year period. However, it might be preferable to take pine martens from a smaller number of sites, in an attempt to translocate mutually familiar animals which might be more useful in a reintroduction (see Chapter 6). Such an approach would also be more cost effective. Thus, if 15% of adults or 10% of adults and sub-adults were removed from any one population, then 15 pine martens could be obtained from only two or three donor populations in one year. Two or three different donor populations would need to be used in the second year of a reintroduction.

Removing only adults, as opposed to adults and sub-adults, would have a slightly greater impact on donor populations. Using only adult animals might however increase the chance successful reintroduction, since there would be a shorter time lag between releases and first breeding in a reintroduction region. These matters are considered further in Chapter 6. Distinguishing adults from sub-adults is possible during the breeding period, but often not possible outside it. Hence it is anyway likely that it would not be possible to translocate exclusively adult animals.

The population model predicted a 20-25% chance that a donor population would decline immediately after 15% of adult pine martens were removed. However, it also showed that there is very high probability that a population would return to its original size 2-5 years after removals. Furthermore, the model was a worse-case scenario; there was no allowance for compensatory increase in fecundity reported for many populations of Carnivores following harvests or unusually high mortality (Clark & Fritzell 1992; Harris 1977; Voigt 1987). The model may well thus over estimate the risk to donor populations. It is also probable that pine martens will disperse into the areas where individuals have been removed from the surrounding untrapped woodland (Fig 4.1). These areas would effectively act as refugia, which have been shown to be important for sustaining annually harvested American marten populations (Archibald & Jessup 1984; Strickland 1994).

Pine martens exhibit strong intra-sexual territoriality (Balharry 1993b) and the removal of some individuals could potentially result in territory breakdown and hence disruption to mating systems locally. However, a study of a harvested population of American martens found no evidence of territory breakdown (Katnik, Harrison & Hodgman 1994). Despite the fact that this population was heavily harvested, martens still exhibited intra-sexual territoriality with 80% of males overlapping the territory of at least one female and no evidence of males becoming transient during the breeding season. The prudent level of removals we suggest should thus not be sufficient to cause disruption to social behaviour in donor populations, any more than that associated with natural mortality.

A programme to restore the pine marten to England would require successive reintroductions to several regions (Chapter 6). Successive reintroductions would be spaced at least two years apart. Our results suggest that the donor populations could certainly sustain the rate of removal of pine martens that such a programme would entail. Animals would need only to be removed from the same donor population at four yearly intervals, at most, and our model shows that this interval would be sufficient for populations to fully recover from previous removals. Nevertheless, it would be vital that the safe rates of removals we suggest were not exceeded, so as to be certain to avoid damage to donor populations.

4.4 Conclusions

4.4.1 Nine regions in Scotland were identified where well established pine marten populations occur at high density. Each of these is estimated to support between 11 and 60 adult (>2 years old) pine martens. Areas around these potential donor regions also support pine martens.

4.4.2 A population model showed that there would be up to a 25% chance of a temporary population decline in the year following the removal of 10% of adult pine martens (or 15% of adults plus sub-adults [2 year olds]) from a donor population. The model further showed that there is at least an 85% chance of a donor population returning to its original size two years after removals and at least a 92% chance of this 5 years on. Removing 10% of adults or 15% of adults and sub-adults from any one potential donor region would thus not damage existing pine marten populations. This level of removals would provide sufficient pine martens for a phased programme of reintroductions to England.

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