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Species Recovery Programme for the pine marten in England: 1995-96

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Summary: The Way Forward for Pine Marten Recovery in England

The case for reintroductions

1. Surveys of 860km of transects in England and Wales have found no convincing evidence of pine martens (Bright & Harris, 1994; Bright, McDonald & Harris, 1995; McDonald, Bright & Harris, 1994). It is certain that populations outside Scotland have not expanded this century, despite many decades of reduced persecution pressure. Furthermore, unofficial releases and miss-identification of casual sightings and scats could have confused the picture of current pine marten status. We conclude that functional, viable populations capable of expansion do not exist outside Scotland.

2. It is also clear that pine martens occurred in relict regions of distribution in England (Cumbria, Northumberland and Yorkshire) and Wales in the last few decades, but that this has not resulted in recolonisation of former range. This is despite documented reduction in persecution pressure (Tapper, 1992). Our analyses (Part 2) show that lack of woodland (and possibly lower prey availability) probably severely constrained pine martens between c.1920 and c.1950 in relict regions. Reafforestation of relict regions probably came too late to allow pine marten populations to recover. The implication is that relict populations were very small and consequently entrapped by stochastic extinction vortices.

In many respects, there is a strong analogy with the red kite: kites have been unable to spread from low quality habitats in Wales, but reintroductions to higher quality habitats in England have been very successful. Some relict regions have recently become more suitable for pine martens as a result of afforestation.

3. The Forestry Commission's reintroduction of pine martens to Galloway has been highly successful and resulted in the establishment of a population that, based on extensive field evidence (Parts 1 & 3), is almost certainly expanding. However the breeding pine marten population has only spread c. 11km in 15 years, partly into low quality habitat where this is contiguous with established territories. This is despite much wider dispersal by pine martens, their capacity to travel long distances (mean 7km $night^{-1}$ in Galloway) and the presence of higher quality habitat close to the limits of current Galloway distribution. Pine martens thus seem to display a considerable degree of philopatry. This means that reintroductions, as with red kites, would return pine martens to regions most unlikely to be colonised in the foreseeable future.

Biological suitability of regions in England for reintoductions

4. A detailed assessment of the *biological* suitability of selected regions in England for pine marten reintroductions was undertaken. This was to determine only whether suitable habitats exist; assessments of other aspects of regional suitability followed by consultation of interested parties would be needed before proposals about reintroductions could be brought forward (see below).

5. Optimal regions for reintroductions and their surrounding areas will have high woodland cover, but be away from areas of frequent gamekeeping. There are seven such regions in England, which were assessed for suitability for establishment and for subsequent spread of a reintroduced pine marten population. Probability of establishment would be an inverse function of violent mortality. Probability of spread should be strongly related to prey availability.

Biological suitability of upland conifer plantations for pine martens

6. Large areas of contiguous wooded land are scarce in England, most that exist being forestry plantations. Purely on the basis of their large area, and consequent potential capability to support viable populations, forestry plantations might therefore provide suitable sites for pine marten reintroductions. However, the autecology of pine martens in continuous forestry plantations, especially in the uplands, was not well known.

7. The Forestry Commission's reintroduction to Galloway has resulted in a relatively high population density of pine martens in mixed conifer habitat on lower ground around Glen Trool. Population density is low in spruce dominated forest on higher ground. Detailed analysis of the behaviour of 13 radio tagged pine martens showed that low food availability in upland spruce was almost certainly the principal cause of this difference in density (Parts 3 & 4). Low availability of preferred den sites in upland spruce might also limit pine martens.

8. A lower proportion of forest canopy cover, than in upland spruce plantation in Galloway, would benefit pine martens: it promotes a more extensive field layer and associated higher abundance of prey. Higher age class diversity of coupes would have a similar effect. Many commercial forest management plans currently call for an increase in both these components of forest structure, to promote sustainability of forest ecosystems. Thus the pine marten's requirements are not an additional constraint on forest design and management. In fact higher densities of pine martens will be good indicators of more naturally structured forests.

9. In terms solely of pine marten autecology we conclude that some commercial coniferous forests in the uplands could clearly be suitable sites for reintroductions. Pine martens would probably achieve lower population densities in upland plantations compared to other potential reintroduction regions in the lowlands.

The case for a staged programme of trial reintroductions

10. Although most potential reintroduction regions have high indices of prey availability, most also have higher *potential* risk of violent mortality (Part 2). We do not know whether this risk would be sufficient to prevent the establishment of reintroduced populations. Hence the most prudent strategy would entail trial reintroductions first to regions of lowest risk of violent mortality. These trials would determine the importance of violent mortality from anthropogenic sources (*eg* roads) and inform choice of subsequent reintroduction regions. This means that the biologically most suitable regions for trial reintroductions would be Kielder, followed by Wareham, Heathfield, Dean and Bovey. Ultimately, regions of greater prey abundance *eg* Heathfield and Dean, might support higher population densities of pine martens.

Consultation and impact assessments

11. This report provides a case for reintroductions to England in terms only of pine marten autecology. Further assessments of the suitability of potential reintroduction regions are now needed in terms of *potential* impacts of pine martens on native fauna and game. These will be undertaken in 1997.

12. It should also be emphasised that consultation with the general public, landowning and field sports interests in potential reintroduction regions would be essential before any proposals for pine marten reintroductions could be brought forward.

13. However, the pine marten remains one of Britain's rarest mammals and has become extinct through human persecution in nearly all of its former distributional range. The species recovery programme for the pine marten is thus of highest priority, especially in England where pine marten conservation status is now so poor.

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Contents

Report Structure and Objectives

This report describes extensive work conducted between July 1995 and December 1996, following field studies that were initiated in 1994 (Bright, McDonald & Harris, 1995). For the sake of clarity the report has been divided into self contained parts, plus a summary. The work had the following highly specific objectives to which we have closely adhered:

> **1.** To identify factors associated with the apparent success of the Forestry Commission's reintroduction of pine martens to Galloway. *This is addressed in Parts 1, 3 and 4.*
>
> **2.** To assess the suitability of habitats for pine martens in areas where they recently occurred or might be reintroduced. *This is addressed mainly in Part 2; the suitability of forestry plantations is also discussed in Parts 3 & 4.*
>
> **3.** To estimate the effects of anthropogenic mortality, such as inadvertent capture in traps or road kills, on a reintroduced population, using data from potential reintroduction sites. *This is also addressed in Part 2.*

A large portion of the work capitalised on a uniquely valuable opportunity to study the growth, and factors associated with success, of a population of pine martens reintroduced to Galloway. Fieldwork on this population has been highly successful and resulted in some important insights for pine marten recovery in England.

Objectives 2 and 3 charged us to assess the suitability for pine martens of habitats in different regions of England. We have assessed many more regions than required by the contract and provided important quantified evidence as to the suitability of habitats for reintroductions and the suitability of relict regions of distribution.

Throughout the project we have received considerable encouragement and help from Tony Mitchell-Jones (English Nature) and Valerie Keeble (People's Trust for Endangered Species), which is very gratefully acknowledged.

Part 1: Expansion of a reintroduced pine marten population: lessons for conservation in England

Introduction

Reintroductions have been widely used in attempts to aid the restoration of biodiversity, but their outcomes have seldom been thoroughly monitored. This is particularly unfortunate as reintroductions into vacant areas have the potential to reveal much about the ecology of threatened, often little known, taxa. Monitoring can show not only whether translocations provide a useful conservation strategy, but also highlight hitherto unsuspectedly important features of a species' ecology, when individuals are exposed to novel conditions (Caughley, 1994).

The pine marten *Martes martes* formerly occurred in Galloway, south west Scotland but became extinct by 1850 (Langley & Yalden, 1977). In 1980 and 1981 the UK Forestry Commission released 12 pine martens in coniferous forest plantations in Galloway. The animals were not marked, nor was their progress monitored, save for the collation of records of sightings (Shaw & Livingstone, 1992). Subsequently, it has become clear that a breeding population is established. Pine martens are now present in newly created upland spruce *Picea* spp. dominated plantations, habitat where their ecology is little known.

Pine martens were formerly distributed throughout Britain, their extinction in Galloway being part of a catastrophic national decline resulting from persecution in the nineteenth century. By 1920 pine martens were reduced to a relict population in north west Scotland and (probably very small) fragmentary populations in northern England and Wales (Langley & Yalden, 1977). Pine martens are currently slowly recolonising northern Scotland (Balharry *et al.* 1996), but populations in England and Wales have not expanded and are functionally extinct (Bright & Harris, 1994). Factors associated with the lack of recovery of pine marten populations in England are addressed in Part 2 and elsewhere. However, it is clear that reintroductions (Whitton, 1990) could well be an effective conservation strategy. Coniferous forest plantations are a potential site for such conservation efforts, being large areas of apparently suitable habitat for this woodland species (Bright & Harris, 1994).

In this part of the report we assess the success of the Galloway reintroduction, fifteen years after initial pine marten releases. We compare total marten population growth predicted from a simple model with empirical estimates of population size. We also examine the pattern of population expansion in relation to release sites and the suitability of new coniferous forest plantations. Our work has clear general implications for reintroductions and was part of the Species Recovery Programme for the pine marten in England.

Methods

Background to the Galloway reintroduction

Pine martens were trapped by Forestry Commission staff at sites in Inverness-shire, northern Scotland and released one to three at a time in Glen Trool (NX4079) or Clatteringshaws (NX4884), Galloway (Shaw & Livingstone, 1992). The two areas are separated by 15km of mountainous terrain. Glen Trool is a lowland site (100m OD) with higher prey availability and habitat diversity, compared to Clatteringshaws (280m OD) which is dominated by monoculture spruce plantation. Releases took place between January 1980 and December 1981, with two males and four females released in Glen Trool and four males and two females released in Clatteringshaws. Animals were not provided with food, nor initially held in pre-release cages and subsequent sightings suggest that they became established in Glen Trool, but not Clatteringshaws (Shaw & Livingstone, 1992).

Population density estimate

Adult breeding pine martens (*ie* 2+ years old) show strong intra-sexual territoriality (Balharry, 1993a). Territory areas of breeding adults, which we determined by radio tracking, can thus be used to estimate population density. Pine martens were captured in cage traps (Tommahawk, Wisconsin), lightly anaesthetised and fitted with 23g radio transmitters (Biotrack, Wareham, Dorset). Procedures closely followed those used by Balharry (1993a) and were licensed in accordance with the Wildlife & Countryside and Animals (Scientific Procedures) Acts. Adult breeding pine martens were recognised by the presence of exposed abdominal scent glands (males and females) and large testes (males), or clearly visible nipples (females; Monte & Roeder, 1990; Balharry, 1993a; D. Balharry, personal communication).

Individual pine martens were tracked continuously from a vehicle and on foot from the beginning to the end of their (generally nocturnal) activity period. An extensive network of forestry tracks allowed their positions to be determined at 5 minute intervals, to the nearest 100m. Locations were established with the aid of detailed Forestry Commission and Ordnance Survey maps. Tracking continued for at least 10 nights or until the minimum convex polygon area enclosed by radio locations reached an asymptote (Harris *et al.* 1990). Territory areas were then calculated using minimum convex polygons (MCPs). All radio locations of martens active, not in dens, were used in the calculations. Following analysis of habitat use by radio collared martens (Part 3) territories were classified as low quality or high quality: the former were dominated by single age sitka spruce plantation, the latter by mixed age and species plantation with larch *Larix spp.* and broadleaved trees.

Distribution survey

Pine marten distribution was determined by searching transects along forest tracks (5m wide) for distinctive marten scats (faeces). These were recognised by their morphology and sweat-musky odour (Lawrence & Brown, 1973; Balharry, 1993a). Only fresh scats (a few days old) with characteristic odour were classified as being from pine martens. This avoided confusion of pine marten scats with those of fox *Vulpes vulpes* or stoat *Mustela erminea* which overlap in morphology, but not odour.

Forested areas within a 60-100km radius of the Glen Trool release site were divided into potential marten areas (PMA), which were discrete blocks of forest or larger forested areas subdivided on the basis of rivers which form boundaries to territories (Balharry, 1993a). Six 2km transects were searched for scats in each PMA.

Habitat selection

The following habitat types were recorded for 200m segments along both sides of transects: (i) regenerating coniferous plantation (trees <2.5m tall); (ii) dense coniferous plantation (field layer <50% cover); (iii) less dense coniferous plantation (field layer > 50% cover); (iv) mixed age coniferous plantation (including >20% of each of i-iii); (v) clear felled coniferous plantation; (vi) deciduous or mixed woodland; (vii) pasture and moorland.

Population model

A simple deterministic Leslie matrix model was constructed using the RAMAS software (Burgman, Ferson & Akcakaya, 1993) to predict total pine marten population size 15 years after reintroduction. There are very few population data on pine martens, so the model was parameterised using data for American martens *Martes americana* which are probably conspecific with *M. martes* (Anderson, 1970). These referred to 6448 animals harvested from a population in Ontario, Canada between 1972-1986 (Strickland & Douglas, 1987). The population was subjected to only a low level of trapping, so we assumed that the data provide reliable estimates of population parameters for a reintroduced (unharvested) population. This gave survival rates of $0.32y^{-1}$ for animals < 1 year old (56% of the population) and $0.60y^{-1}$ for animals 1+ years old. The latter was revised upwards to $0.75y^{-1}$ since harvesting, even at a low level, leads to a reduction in adult and sub-adult survival. Maximum longevity was assumed to be 12 years and the population sex ratio 0.5. Strickland and Douglas (1987) gave fecundities of zero for American martens <2 years old, 2.58 young per female for 2 year olds and 3.5 for older pine martens. We revised these to zero, 2.0 and 3.0 respectively as data from Scotland suggest that pine martens reach breeding maturity later and produce fewer young (D. Balharry, personal communication). These combined data were used to formulate a base model. All simulation results are expressed in numbers of sub-adult and adult pine martens (1+ year olds).

Results

Distribution and breeding

The probability of detecting pine marten scats reached an asymtote after c. 8km of transect had been walked. This suggested that walking 12km of transect within each potential marten area (PMA) would have been more than sufficient to detect pine marten scats if they had been present. In five PMAs five or more pine marten scats were found (mean 5.4 SE 0.24). The mean distance from Glen Trool of these PMAs was 6.8km SE 1.6 (Fig. 1). In five further PMAs one to three pine marten scats were found (mean 1.8 SE 0.37), at a mean distance from Glen Trool of 15.4km SE 2.6 (Fig. 1). The two types of PMAs differed significantly in scat density and distance from Glen Trool (scat density: $U_{5,5}=0$, p=0.004; distance: $U_{5,5}=3.5$, p=0.048).

In Figure 2 the distribution of pine martens according to our scat survey is compared with an independent scat survey and sightings of pine martens (Shaw & Livingstone, 1992; Balharry *et al.* 1996; G. Shaw personal communication; personal observation). All sightings bar one that indicted the presence of breeding pine martens (females with cubs and small juveniles, n=12) fall within PMAs where five or more scats were found; these are henceforth referred to as breeding PMAs. One litter of pine martens was observed just 2km to the west of a breeding PMA. Areas with 1-3 scats are referred to as occupied PMAs.

About 80% of all pine marten sightings fall within breeding PMAs, and 90% fall within PMAs where scats were found. A smaller scale, independent survey confirms these findings (Balharry *et al.* 1996). Our scat survey thus appears to give a reliable picture of distribution, but sightings show that pine martens have ranged widely (up to 70km; Fig. 2) from the Glen Trool release site.

Fig. 1. Frequency distribution of (a) pine marten scat groups (1+ scats together; cross hatched bars) and scat groups per transect^{-1} (dashed line; running mean of three) at increasing distance from the Glen Trool reintroduction site; and (b) 2km transects (n=191) through forest at increasing distance from the Glen Trool reintroduction site. Note that the distribution of transects closely follows that of forest at different distances from Glen Trool.

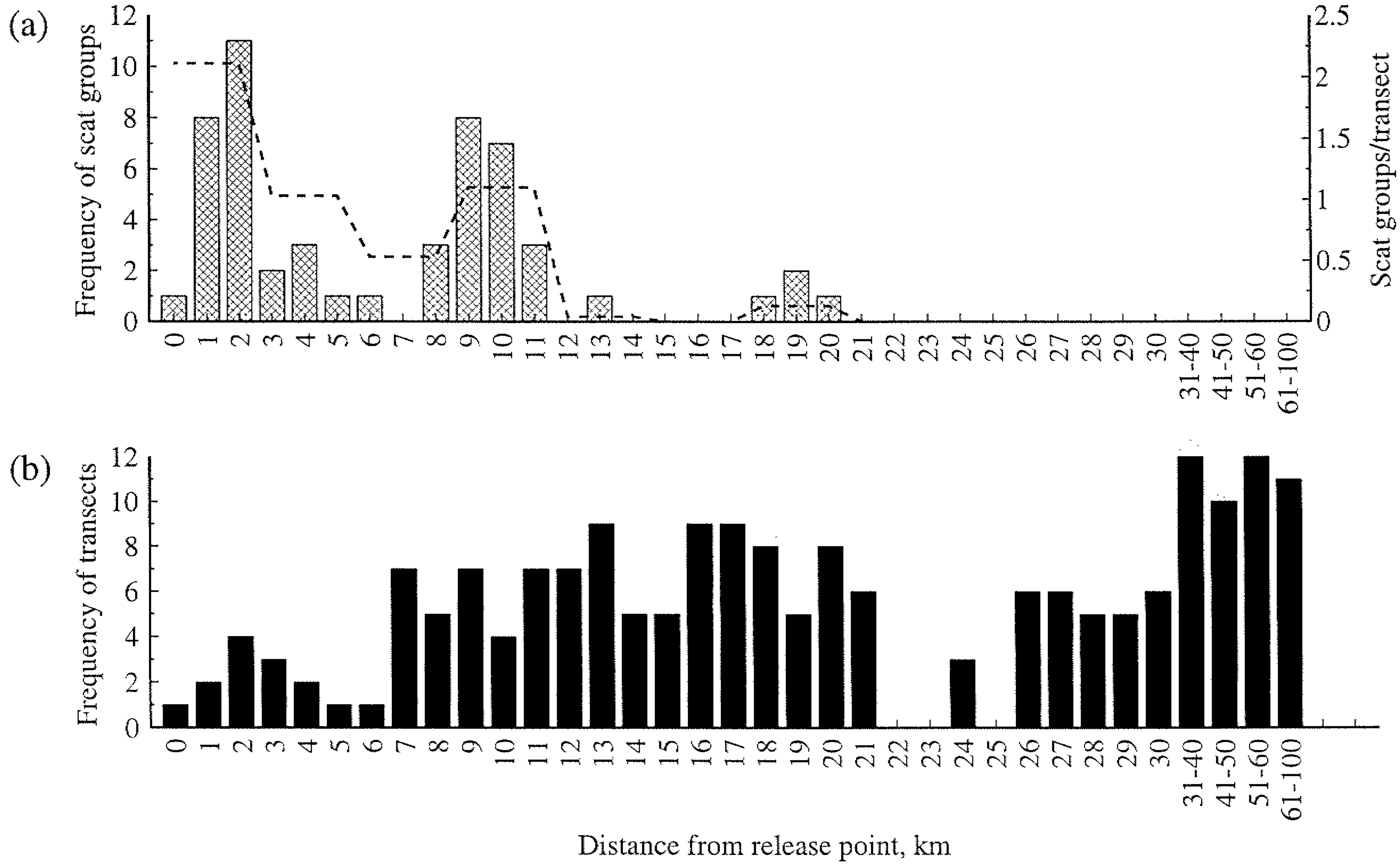
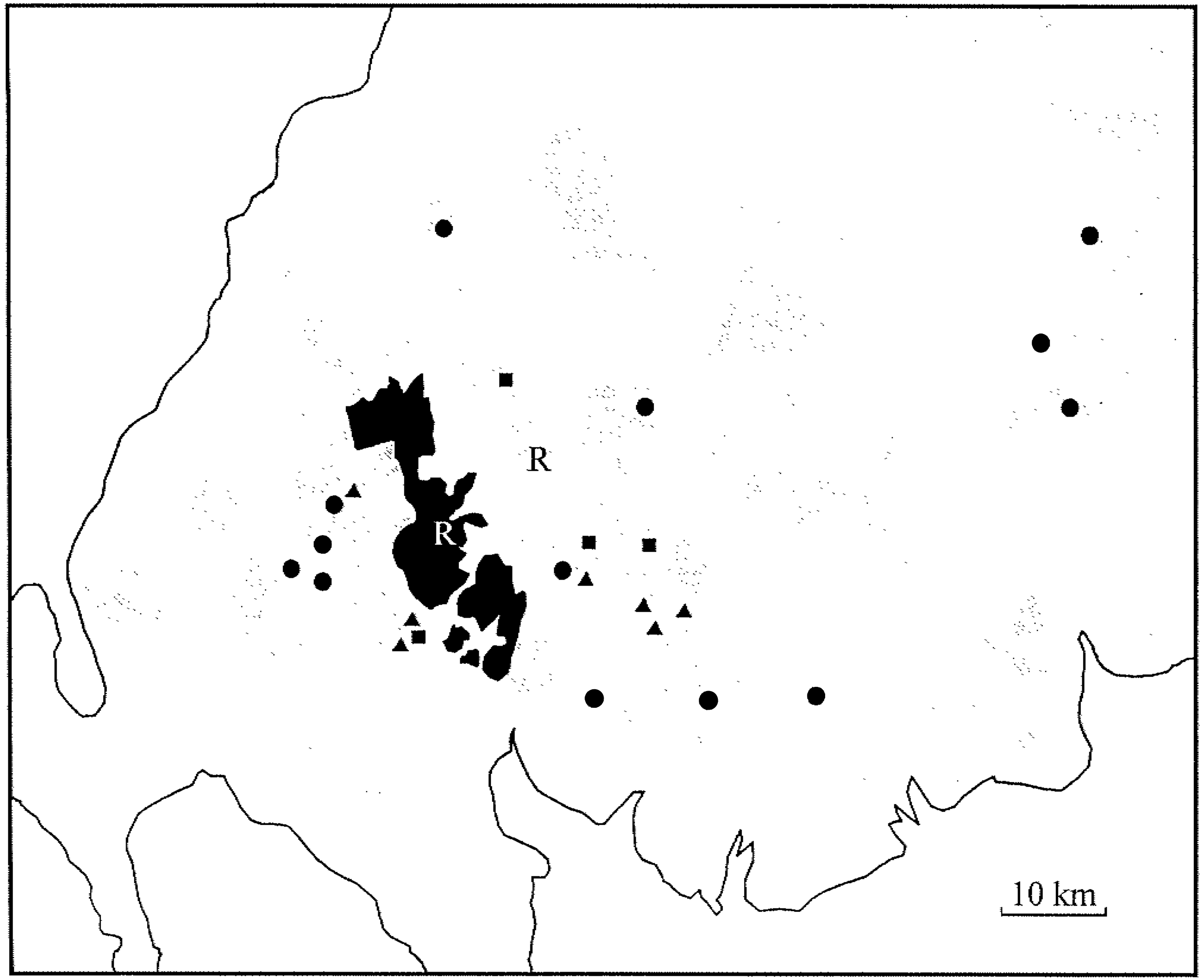


Fig. 2. Distribution of woodland in south west Scotland (grey) and areas where an established, breeding pine marten population is present (black). The latter are referred to in the text as breeding potential marten areas or PMAs and were determined by intensive scat surveys. Sites where pine martens are present (as determined by scat surveys), but probably not established and breeding are shown (black squares). Also shown are sites outside breeding PMAs where scats were found during an independent survey (Balharry, *et al.* 1996; black triangles) and sightings of pine martens outside breeding PMAs; Shaw & Livingstone, 1992). 'R's indicate reintroduction sites at Glen Trool (white) and at Clatteringshaws (black).



Habitat selection

The composition of habitats in breeding and positive PMAs combined was significantly non-random compared to available habitat within all PMAs ($p<0.01$). Compositional analysis was used to rank habitats according to their abundance in breeding and positive PMAs compared to habitat availability in all PMAs. Mixed age coniferous plantation was ranked highest, pasture and moor lowest. There was significantly ($p<0.05$) more mixed age coniferous plantation compared to young coniferous plantation in breeding and positive PMAs, implying that pine martens selected the former but avoided the latter. Thus pine martens may be selecting for certain habitat types, but their pattern of occurrence (as evidence by scats) is at least as suggestive of a radial population expansion from Glen Trool irrespective of habitat type.

Simulated population growth

The base model (adult survival $0.75y^{-1}$) predicted simulated population sizes after 15 years of 39 (founder n=6) and 77 (founder n=12) pine martens. Simulated population size was linearly dependent on founder size. Decreasing adult survival by only 10% (to $0.675y^{-1}$) resulted in a 70% decrease in population size at 15 years (Fig. 3). Data on American martens (the basis of the model; Strickland & Douglas, 1987) suggest that adult survival may vary by 18% $year^{-1}$, although this may be an overestimate because it is based on data from a harvested population.

By contrast, fecundity had much less effect on simulated population size: a 10% reduction in fecundity resulted in a 24% reduction in population size. Strickland & Douglas (1987) recorded variation in fecundity of 12% $year^{-1}$ and this was used to calculate 95% confidence limits for fecundity (Fig. 3).

Estimate of population density

Territory areas (adult, breeding pine martens) were significantly larger for males in upland spruce compared to lowland mixed conifer habitat. The former were also larger than female territories in lowland mixed conifer habitat (Table 1; Friedman ANOVA: $p<0.05$, followed by multiple comparisons among ranks). Territories for adult, breeding pine martens of the same sex were non-overlapping and adjacent. They were thus be used to calculate densities. Female territories were within those of males, so total density of adults was calculated as male plus female density (Table 1). Territories of two sub-adults radio tracked overlapped those of adults (Part 3), as in other studies (Balharry, 1993b). Consequently no simple empirical estimate of sub-adult population density was possible.

Estimate of population size

To calculate population size we assumed that only areas with high scat density (breeding PMAs) contained adult, territorial, breeding pine martens (plus non-territorial sub-adults, see Discussion). Areas with low scat density (occupied PMAs) were assumed to contain only dispersing, sub-adult pine martens. The total area containing adult pine martens was taken as the area of forest within breeding PMAs, since radio tracking showed that 95% of the area within territories was forest. This was multiplied by adult male plus adult female density (Table 1) to estimate the total number of adult pine martens (Table 2).

A second estimate of population size was based on total areas of upland spruce and lowland mixed conifer forest (see Part 3) within breeding PMAs, and corresponding

Fig. 3. Total pine marten population size fifteen years after reintroduction, predicted from a deterministic Leslie matrix model, based on annual survival rates of 0.75 (solid lines) and 0.675 (dashed lines). Lines are for founder populations sizes of 12 and 6 pine martens. Vertical lines show the mean predicted fecundity (solid line) and upper and lower predicted 95% confidence limits of fecundity (dotted lines).

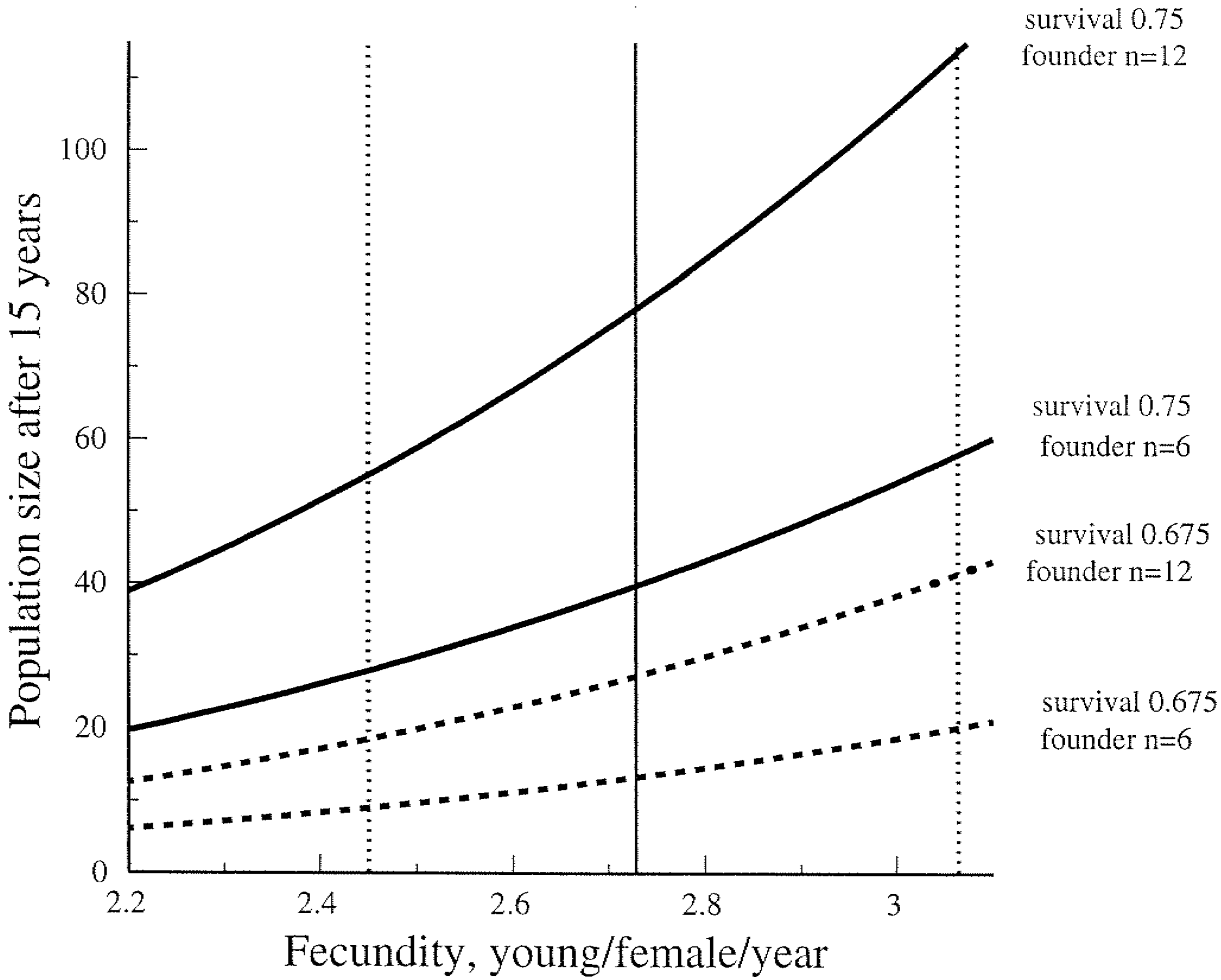


Table 1. Pine marten territory areas, determined using minimum convex polygons (MCPs), and densities calculated from them. Data are for territorial adults (*ie* 2+ years old) of both sexes, in lowland mixed conifer (high quality) habitat and in upland spruce habitat (lower quality). Calculations assume that territories of one sex are contiguous and non-overlapping in forested habitat, and that female territories are overlapped by those of males. Means are shown, with standard errors in brackets.

	n	MCP, km^2 (SE)	Density (1/MCP), km^{-2}	Density of males + females, km^{-2}
Adult males	6	20.61 (7.73)	0.049	0.171
Adult females	5	8.17 (1.65)	0.122	
Adult males, lowland mixed conifer habitat	3	8.36 (1.77)	0.119	0.340
Adult females, lowland mixed conifer habitat	2	4.52 (0.79)	0.221	
Adult males, upland spruce habitat	3	32.86 (12.08)	0.030	0.124
Adult females, upland spruce habitat	3	10.61 (1.22)	0.094	

Table 2. Estimates of the size of the Galloway pine marten population, based on surveyed blocks of forest (potential marten areas; PMAs). Total areas of lowland mixed conifer habitat (low quality) and upland spruce habitat (high quality) occupied by adult, breeding pine martens are shown; together with the total number of this cohort and the total population size. Calculation of the latter is based on the assumption that sub-adult pine martens (*ie* 1-1.9 year olds) constitute 33.5% of the territorial adult population size (see Methods).

Estimate of distribution and density	Area of habitat, km^2		Number of territorial adults (2+ year olds)	Number of sub-adults (1-1.9 year olds)	Total population size (1+ year olds)
Breeding PMAs and density of adults		156	27	9	36
Breeding PMAs and density of adult males and females separately in lowland mixed conifer and upland spruce habitat	Lowland mixed conifer habitat	27	9	3	12
	Upland spruce habitat	129	16	5	21
	Total	156	25	8	33

adult pine marten densities from Table 1. This gave a closely similar estimate population size of about 25 adults (Table 2) and emphasizes that the majority of the adult population occupies upland spruce plantation which is low quality habitat.

We assumed that sub-adult population size was 33.5% of that of adults, based on the stable age class distribution from our population model. This estimate plus adult populations size gave estimates for the total size of the Galloway pine marten population of 36 and 33 adults and sub-adults (Table 2).

Discussion

Validity of assumptions and available data

This study provides rare information on the expansion of a carnivore population, but had to be based on an estimate, not a census, of current population size. We had to assume that higher scat density indicated the presence of territorial, adult breeding pine martens, but this was substantiated by observations of breeding being in areas of higher scat density. Furthermore, although population density estimates were based on only up to 11 pine martens, territories of males and females showed consistent differences in areas for higher and lower quality habitat and it is clear that a large proportion of adults thought to be present (c.40%) were sampled.

Population growth and density

There was good agreement between our empirical estimate of pine marten population size in Galloway with the mean estimate derived from a model for a founding population of six animals. This lends support to observations that only six of 12 pine martens released became established (Shaw & Livingstone, 1992). More importantly, it shows that the growth of the population has been no greater than the mean rate expected for an established population of American martens. This is despite releases being in vacant habitat.

Our estimate of density suggests that diverse tree species and age structure coniferous plantation provides high quality habitat for pine martens. Density was close to the one of the highest reported densities in Scotland ($0.34km^{-2}$ in Galloway *vs* 0.42; Balharry, 1993a). By contrast, upland spruce plantation did not offer good habitat for pine martens. Density was as low ($0.12km^{-2}$) as that in an area of highly fragmented forest (2.5% cover) in north west Scotland, which Balharry (1993a) considered to be poor habitat. This was almost certainly due to low food availability, especially during years when voles *Microtus agrestris*, are scarce (Part 3). Vole abundance would have been low during February-June (pine marten gestation and lactation period) in seven of the 15 years since pine martens were released. It is noteworthy that all observations of breeding females in spruce habitat seem to have been in years of higher vole abundance.

Philopatry and habitat selection

Verified sightings records show that pine martens have travelled up to 70km from the successful release site in Glen Trool (cf Shaw & Livingstone, 1992). This accords with long dispersal distances recorded elsewhere (Balharry, 1993a). Furthermore, radio tracked pine martens in Galloway travelled a mean of 7km per night (Part 3). Yet our surveys and records of breeding show that the established population (*ie* territorial breeding adults) is confined to an 11km radius of Glen Trool. Independent surveys confirm this finding (Balharry *et al.* 1996). The established population has occupied low quality habitats when these were adjacent to other occupied areas.

There was little apparent selection for higher quality habitat and much high quality habitat away from the veracity of Glen Trool remains unoccupied.

These findings suggest a degree of philopatry, with new recruits to the pine marten population settling close to areas already occupied. The resultant radial expansion appear to mirror that documented at a coarser scale for the main pine marten population in north west Scotland (Balharry *et al.* 1996). Philopatry may be a consequence of the pine marten's strong intra-sexual territorial behaviour, which Balharry (1993b) considered inflexible compared with other mustelids.

Lessons for reintroductions

It is clear that the Galloway pine marten reintrodution has been successful. A breeding population is now established, despite only a very small number of animals having been released. Nevertheless the population has not dispersed far. Recolonisation of formerly occupied regions by pine martens can therefore be expected to be slow. However, reintroductions can clearly be effective at establishing new population foci and thus increasing effective rates of spread. Expansion of the Galloway pine marten population mirrors that shown by a range of apparently philopatric species, most notably red kites *Milvus milvus* (Newton, Davis & Moss, 1994). Reintroductions may in general be a useful conservation strategy for such species. Furthermore, philopatry is likely to promote the success of reintroductions, where return to release sites is vital for the establishment of new populations (Bright & Morris, 1994).

It is also clear that pine marten translocations to higher quality diverse age structure habitats have been successful, while those to new spruce plantations have not. The Galloway population has subsequently expanded into adjacent new spruce forest. This highlights an important distinction between habitats where population growth as opposed to establishment can occur: higher quality habitats (or supplementary feeding) will usually be needed for the latter. The suitability of coniferous plantations for pine martens in Galloway and elsewhere in Britain should increase in the next few years as first planting rotations end and forest age structures are diversified. Meanwhile the carrying capacity of the region (Fig. 2) is probably quite low compared to other parts of Scotland.

Acknowledgements

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