

### *Environmental uncertainty*

Increased variation due environmental influences (eg the weather or marten prey availability; environmental stochasticity) was predicted to have a relatively minor impact on population growth rates (up to 8% decrease and 2% increase) and probabilities of extinction (Fig. 7). However, the model was based on data from a population of martens in a stable, predictable continental climate. In a maritime climate such as in Britain, where the weather is much more variable, environmental variation could have a larger impact on demography. Nevertheless, the model suggests that environmental stochasticity would be likely to have a fairly limited impact on martens, probably because they are long-lived and are not highly seasonally dependent.

### **Anthropogenic factors**

#### *Violent mortality: persecution, traffic accidents, poisoning*

The model was highly sensitive to survival rates, a 10% decrease in survival (of adults and juveniles) resulted in a 90% reduction in the population growth rate and a more than eight-fold increase in extinction probability (Fig. 7). This clearly illustrates that marten populations are acutely vulnerable to increased mortality from direct persecution or traffic accidents. Figure 8 gives predicted probabilities of extinction in relation to mortality *additional* to that experienced by Strickland & Douglas' (1987) little-harvested population. Marten populations were not likely ( $p > 0.8$ ) to survive additional mortality of more than  $30\%/yr^{-1}$ . Increasing founder population size up to about 40 martens substantially decreased the predicted risk of extinction. Increasing it beyond this had little further effect on extinction risk (Fig. 8).

#### *Lessons from public attitudes to carnivores and past reintroductions*

In compiling this section we have collectively examined more than 160 scientific papers, theses, reports and articles on the reintroduction of carnivores. This might give the misleading impression that a large body of knowledge exists from which clear lessons for future reintroductions could be drawn. In fact most reintroductions have included no feasibility study and little if any post release monitoring. Consequently most clearly breach IUCN guide-lines on reintroductions (IUCN, 1992) and the reasons for their success or failure are unknown or undocumented or both. Very few studies have examined public attitudes towards carnivore reintroductions. Nevertheless there are clear lessons concerning public attitudes to be learnt from some reintroduction studies.

The first is that attitudes to carnivores in continental Europe are quite different to those prevailing in England. In continental Europe larger carnivores have been the subject of several reintroduction programmes (*e.g.* lynx *Lynx lynx*; Breitenmoser & Breitenmoser-Wursten, 1990) following extirpation through hunting earlier this century. This contrasts strongly with the situation in Britain, where larger carnivores were hunted to extinction in pre-Medieval times (Corbet & Harris, 1991). In Europe, smaller carnivores like the pine marten have not generally been the subject of reintroduction programmes, because they remain widespread and in some places common. A recent extensive review of mammal reintroductions in Europe, for example, reported no cases of pine marten reintroduction (Senotier *et al.*, 1992). In Britain even smaller carnivores, including the pine marten, were exterminated from most areas during the last two or three centuries, because they were perceived as vermin by landowners engaged in game rearing (Langley & Yalden, 1977). Only in

Britain was the intensive rearing and preservation of game-birds commonplace (Tapper, 1993). The perception of small carnivores as vermin remains widespread today among some sections of the community and is perhaps the principal obstacle to pine marten reintroductions in England.

Whilst there have been no quantified surveys of public attitudes, our own experience suggests that martens are not perceived as vermin in continental Europe. This is presumably because they impact little on human activities and because they have always been part of the fauna, so that their presence excites little interest. For example, martens may raid hen houses, but people are used to this and lock their hens up accordingly.

In North America perceptions of carnivores are different again, and are the product of a first world nation interacting with what until relatively recently was a largely pristine 'third world' fauna. Extensive reintroduction programmes and studies of attitudes towards carnivores have been conducted. Despite the still widespread distribution of large carnivores (bears, cougars and wolves) that may be, though rarely, a danger to man, the vast majority of people are sympathetic toward them (Kellert, 1985). This is particularly so if the species concerned are threatened with extinction (Kellert, 1992). However it has been shown that the attitudes of people likely to be directly affected by carnivores can be quite different from those of the population at large. For example most people, including ranch owners, supported conservation efforts for the black-footed ferret *Mustela nigripes*. But ranch owners were strongly antagonistic towards prairie dogs *Cynomys* spp., the principal prey of the ferret and without which it cannot survive, because of the damage they can cause to pasture (Reading & Kellert, 1993). Thus attitudes to carnivores, though generally favourable, depend on their real or *perceived* impact. And the attitudes of a minority of people in critical situations, ranchers in this case, can have a disproportionately large influence on the success of conservation programmes.

Research in north America has also shown that attitudes toward carnivores depend on knowledge about them. Reading & Kellert (1993) found this to be least amongst the group of people likely to matter most to black-footed ferret conservation in the field: ranchers and ranch hands. They felt that increased knowledge through conservation education programmes had the potential to change attitudes amongst these crucial groups of people.

From this brief summary on the attitudes to carnivores, and to their reintroduction, there is one clear lesson. In England, knowledge about pine martens is not likely to be great amongst most sections of the community; the species disappeared over 150 years ago from most areas and is no longer part of country folklore. J. Birks of English Nature, seconded to the Vincent Wildlife Trust, is currently examining attitudes to polecat *Mustela putorius* recolonisation of areas where they have not been present for 150 years; this may provide useful guidance as to the likely reception of pine martens in southern England. Meanwhile it is clear that appropriate public awareness campaigns would be an important prerequisite for pine marten reintroductions to England (Part 5) and might well offer a key to their success.

#### *Present attitudes of countryside and conservation organisations in England*

Questionnaires were sent to 34 organisations, of which 24 (70%) responded within the short time available. Of those who replied, 14 (58%) expressed support for the *principle* of pine marten reintroductions, four (17%) were against and six (25%) did not know. Of those in favour of the principle, nearly all (13/14) attached caveats to their support. The organisations that did not reply to the questionnaire were mostly conservation or wildlife study groups, not organisations whose interests might be perceived to conflict with the principle of pine marten reintroductions.

The following is a summary of the responses received from individual organisations; many provided detailed comments which will be kept on file for future use. In attempting to summarise the various comments, we have tried to compile an overview that provides a fair summary of that organisation's attitudes. Since the feasibility study concluded that reintroducing pine martens to England was premature with our current knowledge (Part 5), no organisation was asked to comment on specific release sites, and their response detailed below is thus simply on the *principle* of reintroduction.

**British Association for Shooting and Conservation.** As a general principle the BASC supports measures to increase the biodiversity of the United Kingdom's flora and fauna, and this can include the reintroduction of a species to parts of its former range. However, for predators such as the pine marten it is imperative to consider the long term implications. Thus release sites would have to be carefully selected to avoid opportunistic feeding on livestock or reared game, and such sites may be difficult to find south of a line from the Humber to Mersey. The BASC would be happy to discuss potential release sites, and would be happy to assist by collecting information through its extensive network of gamekeepers.

**British Association of Nature Conservationists.** No reply received.

**British Field Sports Society.** The BFSS would not support the idea of reintroducing pine martens to England because the Society does not see the need for such a course of action. They argue that the species is not under threat and is expanding its range. They cite reports of pine martens damaging native bird populations, and also believe that more quantified information is needed on the potential impact of pine martens on game-bird populations.

**British Naturalists' Association.** No reply received.

**British Ornithologists' Union.** No reply received.

**British Trust for Ornithology.** The main concern for the BTO would be the potential impact of pine martens on bird populations. Since the BTO had no data on this, they felt unable to comment further. They advised that Roy Dennis should be consulted on the impact of pine martens on nesting birds in Scotland; he detailed losses of a variety of species of birds to pine martens, but concluded that the significant increase in pine marten numbers since the early 1960s was to be welcomed, and losses of rare birds to pine martens was a problem that could, and should, be tolerated.

**Council for National Parks.** No reply received.

**Council for the Protection of Rural England.** No reply received.

**Country Landowners Association.** Refused to provide an opinion in response to our questionnaire.

**Countryside Commission.** No reply received.

**Farming and Wildlife Advisory Group.** No reply received.

**Fauna and Flora Preservation Society.** The FFPS strongly supports the principle of reintroducing pine martens to England, so long as the reintroduction follows

accepted practice such as laid out by the IUCN/SSC Reintroductions Group. The FFPS also expects that the reintroduction will be carried out as part of a scientifically planned and meticulously executed programme. It feels that conflicts with local residents are likely to be more imagined than real, and suggested some principles on which a release site should be chosen.

**The Forestry Authority.** It would be difficult for the Forestry Commission as a whole to say whether it supported the principle of reintroducing pine martens to England until the objectives of the reintroduction were clearer. They foresee a number of conflicts with other wildlife, game-birds and livestock. Furthermore, they are open minded on the issue of reintroducing animals generally, and would prefer to see a range expansion by natural spread. The Authority points out that there have been substantial land-use and faunal changes since the disappearance of the pine marten from England. Thus they would need to be assured that the habitat conditions were favourable for a reintroduction to succeed, and that sufficiently large areas were available that would minimise the impacts of the released pine martens on adjacent land-use interests.

**Game Conservancy Trust.** The Trust believes that the principle may be sound, but in practice may be premature because a) we do not at present understand why the apparent small relict English populations have not expanded their range, b) we need to know much more about the habitat requirements of pine martens before we can judge whether conditions are still suitable, c) we need an impact assessment of their likely effects on other elements of fauna, especially other species with a high conservation value, and d) pine martens in English counties might conflict with human activities much more frequently than in their present localities. The Trust would like to see the present conflicts investigated in detail, and feels that the current legal status of the pine marten would have to be altered should the introduction go ahead. In view of these concerns they feel that a full environmental impact should precede any reintroduction.

**International Carnivore Protection Society.** The Society is very much in favour of reintroducing pine martens to England and has already completed a detailed feasibility study. Their report recommends that restocking existing populations may be preferable to reintroductions, and that these populations would then act as foci for natural spread. A study on the existing relict populations is recommended, to determine their current status and why they have not grown.

**International Fund for Animal Welfare.** No reply received.

**League Against Cruel Sports.** The LACS is very much in favour of reintroducing pine martens to England, but expressed severe reservations as to the impact that the shooting industry would have upon such a venture, and felt that with the wide-spread use of the countryside for field sports, the chances of significant numbers of pine martens surviving is slim.

**Mammal Society.** The Society supports the principle, but with appropriate safeguards to limit conflicts between pine martens and other interests.

**Ministry of Agriculture Fisheries and Food.** The MAFF expressed a number of reservations. These included the possible role of pine martens as a vector of bovine tuberculosis, the possibility that licences for control could be requested if the pine martens caused serious depredations on game-birds, and the possible attitudes of the local populace. In this respect they felt that it would

be important to be able to show that the area had supported pine martens in the past.

**Moorland Gamekeepers Association.** A reply was pending at the time of submitting this report; a response was to be sent after their committee meeting.

**National Farmers Union.** The NFU expressed concern about the principle of reintroducing pine martens to England because of their possible depredations on wild populations of game-birds, and the possible conflicts with the shooting interests of many of their members. The NFU also expressed a concern that any plan should be properly managed to ensure compatibility with current management practices.

**National Trust.** The Trust has no objection to the principle of reintroducing pine martens, but the merits of such a policy should be looked at on a site by site basis. The Trust also felt that much more detail was needed on the details of any such scheme before they would consider supporting a reintroduction. Concern was expressed about possible conflicts with game-bird interests, and the rationale behind the proposal was questioned. In particular, they questioned the possible impact of pine martens on both prey species and other predators.

**Royal Agricultural Society of England.** The Society does not support the principle of reintroducing pine martens to England because of what it termed the likely disruption of the ecological balance, and argued that allowing pine martens to spread naturally from the north of England was a more rational approach.

**Royal Forestry Society of England Wales and Northern Ireland.** The Society supports the principle of reintroducing pine martens to England, providing that it is done properly and after a full feasibility study at each release site. Thus the scheme would need to be based on sound scientific principles. The Society also stressed the need for information on the possible impact of pine martens on wildlife and domestic stock, and would need to be assured that the reintroduction of pine martens did not impose limitations on the management practices currently in operation in woodlands in the area. The Society suggested the need for a pilot study, and that any animals released should be recaptured if any unforeseen problems arose.

**Royal Society for Nature Conservation.** No reply was received, although the Gloucestershire Wildlife Trust wrote to support the principle of reintroducing pine martens to England and advocated the Forest of Dean as a potential release site.

**Royal Society for the Prevention of Cruelty to Animals.** The RSPCA, being a welfare organisation, has no views on the conservation arguments for or against a reintroduction, but expressed reservations about the welfare aspects of releasing animals in areas other than where persecution, whether intentional or accidental as a result of the control of other predators, was likely to be minimal.

**Royal Society for the Protection of Birds.** No reply received.

**Smallfarmers' Association.** The Association felt unable to comment, not having the relevant expertise.

**United Kingdom Egg Producers Association.** Their committee had no views on the issue.

**Universities Federation for Animal Welfare.** UFAW are in favour of reintroducing pine martens to any part of their former range, because it would increase the diversity of the ecosystem. However, the organisation stressed the need to conform to accepted guide-lines, including those laid down by IUCN and themselves. UFAW also stressed the need to consider carefully a number of potential problems, including the suitability of captive-bred animals, should these be used, the area and suitability of the habitat around the release site, and public relations.

**Wildfowl and Wetlands Trust.** The Trust supports the reintroduction of animals to their previous range, provided that this satisfies the criteria laid down by the IUCN. They identified a number of potential problems that should be addressed; these included potential conflicts with waterfowl collections and livestock, and the suitability of the animals used for the reintroduction.

**Woodland Trust.** The Trust would be happy to support the principle of releasing pine martens in Trust woodlands, subject to a) identifying the detailed habitat requirements for pine martens, b) sites being chosen where the habitat is already suitable and existing long term management intentions are for this habitat are to be maintained, c) there being no need to undertake specific management for pine martens, d) suitable release sites can be identified for the project.

**World Wide Fund for Nature.** No reply received.

**Zoological Society of London.** The Society supports the principle of reintroducing pine martens, but with certain caveats. These include the provision of adequate resources for long-term post-release monitoring, the genetic origin of the released stock, possible conflicts with other predators and the perceived threats with pheasant-rearing and poultry farming. Subject to these issues being addressed, the Society expressed its desire to help with the project through the provision of facilities such as captive breeding, stud books or the veterinary screening of release candidates.

## Conclusions

Our model of pine marten populations was a best case scenario, and population performance might well be lower than that we modelled. Nevertheless we believe that the model provides robust predictions about the likely success of a released marten population. It shown that pine marten populations can withstand only low levels of mortality, vulnerability which is likely to be enhanced by inflexible territorial behaviour (Balharry, 1993). This conclusion is strongly supported by the past and present vulnerability of martens to anthropogenic causes of mortality.

Marten populations were extirpated over much of Britain and from large areas of north America by trapping (Langley & Yalden, 1977; Berg, 1982). Trapping remains the largest cause of reported mortality in Scotland (Velandar, 1983), while road traffic accidents are also reported as important causes of mortality in England (D.J. Jefferies, *pers. comm.*). It would be essential to the success of a reintroduction or restocking project to ensure that such mortality was very low. Given road densities (Part 2), mortality due to traffic accidents is likely to be higher in England than in much of Scotland. Evidence to support this assumption comes from another small mustelid; it is thought that increased mortality of polecats on roads in England is reducing their rate of spread out of Wales (Harris *et al.*, 1994). Perhaps more importantly, known gamekeeper densities are high in the regions of England otherwise most suitable for reintroductions (Part 2). The number of gamekeepers has fallen dramatically since

pine martens were last present in much of England, but these are still higher than in most areas of Scotland where martens currently occur (Tapper, 1993). It is thus uncertain whether gamekeeping, the direct cause of past marten decline, is now at a sufficiently low level to allow marten populations to survive in much of England. A field assessment of the likely effects of gamekeeping in certain regions is an important priority for the future (Part 5).

Furthermore our assessment of human attitudes has highlighted the historic and continuing view of some sections of the community of small carnivores as vermin. The tacit support of these people would probably be essential to the success of a reintroduction. The very constructive suggestions put forward by the British Association for Shooting and Conservation and by the Game Conservancy Trust, give considerable hope that in some parts of England pine martens could be accepted in the future. Surveys in north America and a recent opinion poll in *BBC Wildlife* magazine rating otters as the most popular animal in Britain, both suggest that the public at large would be highly supportive of pine marten reintroductions. Their support would be essential, but that of shooting interests would be more critical. Scottish Natural Heritage are currently investigating ways to minimise the impact of martens on gamebird rearing interests. Such work, including an impact assessment, followed by publicity promoting the facts about martens, would be essential before reintroductions (Part 5).

The low productivity of marten populations evident from our model, shows that it would also be essential to conduct releases in especially favourable habitats. It would probably be very difficult to establish populations in sub-optimal habitats, even if rates of violent mortality were low.

We were originally charged with assessing the feasibility of marten reintroductions south of the rivers Humber and Mersey. Irrespective of the apparent recent decline of martens in northern England (Part 1), we believe that is not yet certain whether gamekeeping in southern England is now at a sufficiently low level for marten populations to survive in regions which otherwise seem to offer suitable habitat (Part 2). Until this is determined, marten reintroductions to southern England would clearly breach the most essential of IUCN guidelines (IUCN, 1992), that the factor causing a past decline has been removed. This is supported by the views of organisations in agreement with the principle of marten reintroductions: nearly all suggested that further research was essential before reintroductions went ahead.

The situation in those parts of northern England where martens may still survive, is more favourable. Restocking, as suggested alongside reintroductions in the Species Recovery Programme (Whitten, 1990), would be a valuable conservation measure. However, we strongly believe that restocking should not be conducted until the cause of recent marten decline in northern England is clear and until some crucial aspects of habitat suitability have been assessed. Full recommendations are given in Part 5.

## PART 4: A POTENTIAL METHODOLOGY FOR TRANSLOCATIONS

### Introduction

Two important ideas underlie the translocation of birds and mammals: (1) wild-caught animals have higher survival rates than captive-bred animals; and (2) animals acclimated to a novel site before release have higher survival (Bright & Morris, 1994). The second of these has been tested by Davis (1978) who compared the post-release behaviour of American martens that had been held in pre-release cage (a soft release), with martens that were not (a hard release). Deer carcasses were placed near release points to provide food and encourage martens to remain in the release area. Davis (1978) found that hard released martens usually failed to establish a new territory and often travelled tens of kilometres from release points. It seems likely that they had a lower survival than soft released martens, which usually remained near their release points. These differences were probably the result of hard releases being disorientated by sudden translocation and travelling further because they had no attachment to a particular site (Davis, 1978; c.f. Bright & Morris, 1994).

There is thus a foundation of controlled research which demonstrates that soft releases are an effective translocation technique for martens. More is known about martens in this respect than about most other factors likely to affect the feasibility of reintroductions. Previous parts of this report have shown that marten translocations would be premature with our current knowledge, but that they might be feasible in the light of future research. In this part of the report we will thus examine the behavioural basis for marten translocations and outline various practical options which might be pursued in the future. The translocation scenarios we propose are merely meant to provide a basis for discussion and further development, they are not necessarily wholly ideal or practical ways in which to proceed.

### A behavioural basis for marten translocations

It is sometimes possible to identify features of pivotal importance in the life history of more specialised mammals, from which all other facets of their ecology flow. This would seem to be the case with pine martens, for which territoriality and dependence on woodland (Balharry, 1993) have far reaching consequences, especially for translocations.

Strong intra-sexual territoriality leads to martens living at low population density in what Balharry (1993) suggests is an inflexible territorial system. Disruption of this system, due to mortality or translocation for example, might result in: (a) dispersal due to lack of conspecifics or renewed territorial pressure from them (c.f. Lockie, 1966); and (b) prevention of breeding due to infanticide (Balharry, 1993) or missed mating opportunities. It is important to appreciate that martens are solitary animals with a short oestus, so opportunities for mating must be few. Furthermore, there is a six month period of delayed implantation during which stress (perhaps due to conspecifics or translocation) might result in abortion. It is not just that few young can be produced, but that the chances of total reproductive failure are probably quite high due to a rigidly time-structured breeding schedule. The behaviour of captive martens, in which high levels of aggression between unfamiliar animals are usual, emphasises the importance of social ties between individuals. A loss of social cohesion might therefore result in a succession of breeding failures (D. Balharry, *pers. comm.*) which our computer simulation showed would soon lead to population extinction (Part 3).



It is thus apparent that territoriality in martens, and its corollaries of low population density, slow breeding and vulnerability of the social system to mortality, would heavily influence the success of a translocation.

Dependence on woodland appears to be a manifestation of the martens' hunting strategy, constrained by the avoidance of predators (Balharry, 1993) and perhaps competition from other carnivores. It means that martens are most successful in open woodland where their prey can be abundant and in regions with much woodland. The 'optimal' micro-habitat for martens, vole-rich patches within woodland (Balharry, 1993), must be relatively scarce in England, as are large tracts of woodland (Part 2). A need to hunt in a particular type of woodland is thus likely to have profound implications for marten translocations.

Territoriality and woodland dependence therefore seem crucial. By comparison, other features of the martens ecology, such as food preferences, probably have insignificant consequences for translocations.

### Source of martens for translocation

We showed in Part 3 that a large number of martens, 30 to 40, would be needed to found a viable restocked or reintroduced population. At present fewer than 30 pine martens are probably maintained by zoos and wildlife parks in Britain, and their numbers are declining each year (D. Gow, *pers. comm.*). So at present, it seems that there would be insufficient martens from captive sources to supply a translocation project. Substantial investment, even if much of it was voluntarily undertaken by wildlife parks, and several years would be needed to increase this captive population sufficiently to supply a translocation.

Furthermore, there is a large body of evidence showing that captive bred mammals survive and perform after translocation much less well than wild-caught ones (Griffith, *et al.*, 1990; Bright & Morris, 1994). Based on data from wild martens, our computer simulation demonstrated that a founder population would be very vulnerable (Part 3). Captive bred martens, with lower fitness than wild martens, would be less likely to found or bolster a viable population. The widespread and apparently successful use of captive-bred otters *Lutra lutra* for restocking in England (Jefferies *et al.*, 1986), might seem to contradict this conclusion. However, the relative success of captive bred and wild caught otters after translocations has not been compared. And, crucially, the otter lives in riparian habitats where it probably encounters fewer hazards (*e.g.* traps) and hunts far more easily (otters swim with their prey) than do martens in more three dimensional terrestrial habitats. The experience with otters may in fact not be very relevant to pine marten translocations. We believe therefore that translocations will need to use wild caught pine martens.

The contract asked us to enquire whether Scottish Natural Heritage would be likely to licence the removal of martens from Scottish populations for translocation to England. In a letter to SNH we asked: "*Would SNH be willing in principle to licence the live-trapping of martens and their translocation to England for reintroduction or restocking, under the following, at present most likely, scenario:*" The scenario given was a precis of this section of the report. The following reply dated 20 January 1994 was received from Dr D.

Balharry on behalf of SNH: "*In principle the idea of obtaining marten from Scotland gives us no problems provided translocation guidelines are followed (e.g. that donor populations are not damaged) etc and that the plan has been approved by EN and JNCC. If we received an application to take martens we would consult with our Regional staff but I can foresee no major problems.*"

## Timing of translocations

As with other mustelids (Harris, Jefferies, Cheeseman & Booty, 1994) it would be vital to trap martens for translocation outside the time when females would be pregnant or have dependent young (Corbet & Harris, 1991). This means that trapping would need to be conducted between August and February. Trapping after the mating period (July, August) would probably be unavoidable and would offer the only prospect of births in the first years of a release, an important goal. Trapping during this time might however risk females aborting unimplanted blastocysts.

## Potential translocation protocol

The forgoing discussions prompt the following suggestions of possible translocation scenarios. These differ in probable costs and timing, as well as their potential for success. For all scenarios the aim should be to release an even or female biased sex ratio of martens that are a year or more old. Martens should be released at high population density ( $0.5/\text{km}^2$ ), provided this will not lead to aggression between neighbouring individuals.

### *Scenario 1*

Martens would be trapped at one or more areas and held at a release site in individual cages. There would be no assumption that martens were mutually familiar. A male and a female would be held in adjacent cages to promote mutual familiarity before release. After a relatively long acclimation period, perhaps two-three weeks to accustom martens to each other as well as the release site, females would be released. Males would be released some days later. The prior presence of free-living females might encourage males, which are more likely to wander (Davis, 1978), to be philopatric. This scenario would be logistically easier and less costly than either of the two which follow. However, probable lack of long-term familiarity between martens might lead to fatal aggressive encounters and induce dispersal. It might be judicious to release martens of the same sex more than one territory diameter apart; this seemed to avert aggression between reintroduced dormice (PWB, *pers. obs.*), but would compromise the establishment of a cohesive, high density population (c.f. Bright & Morris, 1994).

### *Scenario 2*

Mutually familiar martens, occupying the same territory, would be trapped and released together. This would reduce the likelihood of aggression and martens would not need to be familiarised with each other at the release site. More than one female could be released with a male, provided they originated from the same territory, a method which would not be sensible under Scenario 1 (where females would need to be released from the same place as a male). Experiments to determine the effect of placing marten scats around a release site, to simulate normal territory marking, might be worthwhile (Part 5). This would necessitate more intensive trapping than Scenario 1 and be more costly, but in our view could lead to significantly greater success.

### *Scenario 3*

This would be identical to Scenario 2, except that males would be released before females. Females would be held in cages at the release site until after kits were, hopefully, born in April or May. This might protect females from post-release mortality until after they had contributed to the  $F_1$  generation. However, untamed

caged martens could be a problem to maintain for several months (eg breakage of canine teeth would be likely) and caged females might not be an effective attractant to males (c.f. Scenario 2). This scenario would be the most costly of the three and trials would probably be needed to see if it would be as, or more, effective than Scenario 2. Hobson, Proulx and Dew (1989) showed that female marten released with their young were less likely to disperse than females released without young, even if a soft release technique was used.

### **Post-release monitoring**

The design of a full post-release monitoring programme should await the formulation of a translocation protocol. However, it would be important that the translocations were designed as factorial experiments to control for as many potentially confounding variables as possible. All released martens should be individually marked by tattooing in the ears and/or with ear tags. It would almost certainly be necessary to radio tag and track all released martens and we strongly suggest that the most reliable radio transmitters (in our view from Telonics Inc., Mesa, Arizona) are used, otherwise tag failure is likely to compromise monitoring. Though soft released martens should remain in their release area, it is likely that they will undertake exploratory forays of 20km or more (Davis, 1978). A light aircraft would be needed to follow such movements, though marten would be very likely to return to their release site afterwards.

### **Practical matters**

Whatever translocation strategy is adopted, the following practical considerations are likely to be important. Care of the martens' teeth, while in transport and in pre-release cages, would be vital; they are prone to break canines in traps and cage wire (Davis, 1978; D. Balharry, *pers. comm.*). Careful design of cages would help minimise this problem, as with other mustelids (Harris *et al.*, 1994). Veterinary screening immediately prior to release would be important to avoid releasing animals that were in any way below par. Supplementary feeding at release points, to encourage site fidelity, and nestboxes might also be useful.

## **PART 5: RECOMMENDATIONS FOR FURTHER RESEARCH AND PRACTICAL CONSERVATION IN ENGLAND**

This report has shown that pine martens are probably on the verge of extinction in England (Part 1), though they may still be present in Kielder Forest. It is clear that the pine marten is likely to be the most endangered mammal in southern Britain and worthy of substantial conservation support. Our survey, and subsequent analyses in Parts 2 and 3, lead to revision of the current contract objectives (see Introduction). Consequently, in this part of the report we give broad recommendations about measures to instigate recovery of the marten in England, in addition to those concerning the feasibility of reintroduction.

The most important task for the future must be to determine whether martens still occur in Kielder Forest (and north Wales where their status is also unclear) and the reasons for their apparent recent decline. These questions need to be answered before translocations to restock the northern relict populations are attempted, measures which themselves should pre-date trial reintroductions to southern England. Reintroductions south of the rivers Humber and Mersey are not an immediate prospect. In particular, habitats for martens in southern England must first be examined in detail and an assessment of likely marten impact conducted. However reintroductions to southern England remain a high conservation priority for the future.

Reintroductions and restockings have the potential to contribute substantially to the recovery of the pine marten (Whitten, 1990) and to the restoration of biodiversity to which the Government is committed. Our findings in Part 1 make such conservation measures all the more important. We believe that reintroductions and restockings would almost certainly enjoy the enthusiastic support of the overwhelming majority of the community, but that the support of a significant minority would be crucial (Part 3). For this reason we strongly recommend that pine marten translocations are only conducted under the direct aegis of, or under contract to, the Statutory Nature Conservation agencies (particularly English Nature), so that the highest possible importance is seen to be attached to them.

We recommend the following staged programme of conservation research and practise, that would culminate in a restocking and reintroduction programme provided that the work outlined showed that this was appropriate. We have provided a potential timescale for each of the Recommendations, which show the earliest practical start dates for each recommended project and that marten reintroductions could be conducted in the fairly near future.

### **(1) Field evaluation of marten survey methodology**

*Timescale: summer 1994 or 1995.*

We had intended to test our survey methodology, but were unable to do so due to lack of martens in England. This needs to be done, so that measures of statistical reliability can be attached to future surveys. Work would need to be in Scotland and determine detection functions (Buckland *et al.*, 1993) for marten scats in different habitats. It would also be important to assess the affect of transect length and inter-transect spacing on probabilities of detecting marten scats. A quantified measure of the influence of season on scat detectability would also be useful. Fully quantifiable survey methods would be essential to adequate post-release monitoring of translocated martens.

## **(2) Larger scale surveys in the Kielder region**

*Timescale: summer 1994 or 1995.*

Both the current survey and the 1987-1988 one could not cover all areas of forest around Kielder. This needs to be done to establish whether martens are really present. We suggest that each tetrad (four 1km-squares) with more than 50% woodland is surveyed, probably using three or four 2km transects per tetrad. Surveys need to be conducted during the martens' breeding period, when scat deposition rates appear to be highest (Lockie, 1964), *i.e.* between about May and September.

## **(3) Determination of minimum area requirements**

*Timescale: summer 1994 or 1995.*

Existing evidence shows that martens are strongly linked to woodland. However, there is no quantified information on the minimum areas of woodland needed by martens, with the exception of Balharry's (1993) work based on only two sites. This information is needed to show where translocation efforts, and efforts to conserve existing populations, should be targeted. An extensive survey is required to determine the incidence of martens (as measured by scats found) in woodland of different sizes. This would need to be done in an area in Scotland with a spectrum of different wood sizes and where woodlands are heavily fragmented; minimum area effects would be masked if surveys were done in areas of unfragmented woodland.

## **(4) Field studies of limiting factors in relation to decline in England and Wales**

*Timescale: post Kielder survey, for three years i.e. autumn 1994 or 1995 to autumn 1997 or 1998.*

The contract asked us to assess what factors might be limiting pine marten populations in England. This we have done, providing suggestions and ideas throughout this report. However, these can only be informed guesses based mostly on one large scale study of pine martens (Balharry, 1993) in habitats generally quite different to those in England and Wales. A detailed field study of the limiting factors is now an important priority, especially in the light of the apparent recent decline of martens in England. It is essential to determine what factors have led to the decline and might prevent martens recolonising parts of their former range. An understanding of these factors is vital to allow restocking and reintroduction programmes to be planned.

We recommend that field studies should address the following five main questions: (i) Is the availability of prey-rich areas significantly limiting pine marten abundance? (ii) Is the availability of suitable den sites restricting pine marten populations? (iii) Is woodland fragmentation affecting pine marten behaviour? (iv) What is the impact of human disturbance on pine marten behaviour and reproductive success? (v) To what extent is violent mortality limiting pine marten numbers? Field studies should preferably be conducted on a relict population of martens (*i.e.* in Kielder or north Wales). If these populations are found to have become extinct, the study should be done in a carefully selected area of Scotland where habitats are closely similar to places in England where martens have become extinct. This means that the study must be conducted in an area where martens are likely to be under some pressure from violent mortality, in woodland types found in the lowlands and in places where woodlands are fragmented. The study area would then contrast strongly with the areas where Balharry (1993) worked and with the Black Isle where ITE Banchory are currently conducting marten studies. Answering the questions posed above would probably take two to three full years and clearly entail a major project, but would be vital to gain a full understanding of the factors limiting relict and reintroduced populations.

**(5) Field surveys to evaluate the suitability of the Kielder region**

*Timescale: after a minimum of 1.5 years field study (4), i.e. summer 1996 or 1997.*

This work could be conducted in conjunction to that for Recommendation (4) and would be the basis for a decision as to whether translocations to the Kielder region should proceed. It would obviously be unnecessary if work for Recommendation (4) was pursued in the Kielder region. The surveys would need to address the five questions listed in (4) above, particularly with reference to the availability of suitable den sites and foraging habitats.

**(6) A public awareness campaign in the Kielder region**

*Timescale: after a minimum of 1.5 years field study (4), i.e. summer 1996 or 1997.*

If (4) and (5) demonstrated that Kielder would be capable of supporting a viable marten population, a marten awareness campaign should be initiated and continued during and after translocations (7). The campaign should target sections of the community potentially affected, or who might perceive themselves affected, by marten translocations. It should be run in conjunction with the Forestry Commission and shooting organisations, especially the British Association for Shooting and Conservation and the Game Conservancy Trust (see part 3). The campaign should be extended to schools, Women's Institutes and other locally-based community organisations where appropriate.

**(7) An experimental restocking programme in the Kielder region**

*Timescale: autumn-winter 1996 or 1997.*

This should only be initiated after the preceding Recommendations have been addressed. The objective would be to re-establish a viable marten population in Kielder, but also to assess the effectiveness of different release scenarios. We do not suggest that extensive trials of all the scenarios outlined in Part 4 are conducted, as this would be expensive and insufficient pine martens would be available. Rather, we recommend that the effects of releasing one sex before the other and the effects of placing marten scats around release sites are determined. These might lead to a substantially improved translocation protocol, at small extra cost or additional risk to translocated martens. Other similar, low impact, experiments might also usefully be conducted.

**(8) Formulate methods to avoid conflict with game-bird rearing**

*Timescale: determine methods at least 2 years before a reintroduction i.e. by autumn 1996 or 1997.*

An essential prerequisite for reintroductions to southern Britain would be to devise ways of limiting the inadvertent impact of intensive game-bird rearing operations on martens and *vice versa*. Scottish Natural Heritage have initiated studies to examine these matters, and their results will obviously be of great relevance to reintroductions. The key matters to address concern ways of keeping martens out of pheasant rearing pens and ways to reduce the probability of martens being inadvertently caught in tunnel traps or snares.

**(9) Determine habitat suitability in southern Britain**

*Timescale: autumn-winter 1997 or 1998.*

This work would follow from (4) and (5). In particular it would be essential to assess whether sufficient marten prey and within-woodland foraging habitats were available, and to determine the potential, inadvertent, impact of gamekeeping activities on martens. Field surveys would be essential and should include comparative assessments of gamekeeping activities in potential reintroduction areas and in areas where martens are still present.

**(10) Conduct an assessment of the potential impact of martens in southern Britain**

*Timescale: autumn-winter 1997 or 1998.*

We recommend that an assessment of the true impact of martens on game-bird rearing near potential reintroduction areas is undertaken. This would be based on fieldwork conducted elsewhere (4 and 8 above) and need to provide unambiguous evidence as to the extent and nature of any impacts. It could also include an assessment of the interaction of martens with other species of conservation concern, but on current evidence we believe martens are not likely to have any significant impact on other wildlife in southern England.

**(11) A public awareness campaign in southern Britain**

*Timescale: spring-summer 1998 or 1999.*

This would duplicate (4), but would probably need to be on a larger scale.

**(12) Reintroduction to southern Britain**

*Timescale: two years after Kielder restocking i.e. autumn 1998 or 1999.*

At present there is a clear lack of a sound scientific basis on which to undertake reintroduction of pine martens to southern England. However, this should not be taken to suggest that we do not support the principle of reintroducing pine martens and we strongly recommend that the option of reintroductions to southern Britain is actively pursued, for the reasons outlined in the introduction to this part of our report. Thus in this last section of the report we have suggested a programme of research that will provide the data needed for a full-scale reintroduction, which is possible before the end of the century.

**ACKNOWLEDGEMENTS**

We owe a considerable debt to Dr David Balharry for sharing his hard-won information and ideas on pine martens and for visiting Cumbria with PWB during the survey. We are also particularly grateful to Dr A.J. Mitchell-Jones for his help and continual support during this work and to Dr D.J. Jefferies for discussion of marten distribution. John A. Burton provided many ideas, much information and enthusiasm for this study, for which we owe considerable thanks. Others provided help in numerous ways, including G. Shaw, J. Webster, Dr S. Tapper and Dr P.A. Morris.

**REFERENCES**

Allen, A.W. (1984) Habitat suitability index models: marten. Fish and Wildlife Service, Fort Collins.

- Anderson, E. (1970) Quaternary evaluation of the genus *Martes* (Carnivora, Mustelidae). *Acta Zoologica Fennica* 130, 1-132.
- Archibald, W.R. & Jessup, R.H. (1984) Population dynamics of the pine marten (*Martes americana*) in the Yukon Territory. In: *Northern ecology and resource management*. The University of Alberta Press.
- Balharry, D. (1993) Factors affecting the distribution and population density of pine martens (*Martes martes*) in Scotland. Unpublished Ph.D. thesis, University of Aberdeen.
- Berg, W.E. (1982) Reintroduction of fisher, pine marten and river otter, pp 159-173. In: *Midwest furbearer management, proceedings of the 43rd Midwest Fish and Wildlife Conference* (ed. G.C. Sanderson). Wichita, Kansas.
- Breitenmoser, U. & Breitenmoser-Wursten, C. (1990) Status, conservation needs and reintroduction of the lynx (*Lynx lynx*) in Europe. Council of Europe, Strasbourg.
- Bright, P.W. & Morris, P.A. (1994) Animal translocation for conservation: performance of dormice in relation release methods, origin and season. *Journal of Applied Ecology*. In press.
- Bright, P.W., Mitchell, P. & Morris, P.A. (1994) Dormouse distribution: survey techniques, insular ecology and selection of sites for conservation. *Journal of Applied Ecology*. In press.
- Buckland, S.T., Anderson, D.R., Burnham, K.P. & Laake, J.L. (1993) *Distance sampling: estimating abundance of biological populations*. Chapman & Hall, London.
- Burgman, M.A., Ferson, S. & Akcakaya, H.R. (1993) *Risk assessment in conservation biology*. Chapman & Hall, London.
- Carbyn, L.N., Armbruster, H.J. & Mamo, C. (1993) A review of the results of the swift fox reintroduction program in Canada. *Restoration of endangered species* (eds M.L. Bowles & C.J. Whelan). In press.
- Clinging, V. & Whiteley, D. (1980) *Mammals of the Sheffield area*. Sorby Record Special Series, 3, 1-48.
- Corbet, G.B. & Harris, S. (1991) *The Handbook of British Mammals* (3rd editin). Blackwell Scientific Publications, Oxford.
- Cresswell, P. Harris, S. & Jefferies, D.J. (1990) *The history distribution, status and habitat requirements of the badger in Britain*. Nature Conservancy Council, Peterborough.
- Davis, M.H. (1978) Reintroduction of the pine marten into the Nicolet National Forest, Forest County, Wisconsin. Unpublished M.S. thesis, University of Wisconsin.
- Grakov, H.H. (1972) Effect of concentrated clear felling on the abundance of the pine marten (in Russian with English summary). *Biuletin Moskovskoe Obschestvo Ispytat elci Prirdy Otdecbiologicheskii* 77, 14-23.
- Griffith, B., Scott, J.M., Carpenter, J.W. & Reed, C. (1989) Translocation as a species conservation tool: status and strategy. *Science* 245, 477-480.



- Hagmeier, E.M. (1961) Variation and relationships in North American marten. *Canadian Field Naturalist* 75, 122-138.
- Harris, S. Morris, P.A., Wray, S. & Yalden, D.W. (1994) A review of the status of British mammals. *Mammal Review*. In press.
- Harris, S., Jefferies, D.J., Cheeseman, C.L. & Booty, C. (1994) Problems with badgers? Royal Society for the Prevention of Cruelty to Animals, Horesham, Sussex.
- Hill, M.O. (1979) TWINSPLAN - a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, Itaca, New York.
- Hobson, D.R., Proulx, G. & Dew, B.C. (1989) Initial post release behaviour of marten *Martes americana*, introduced in Cypress Hills Provincial Park, Saskatchewan. *The Canadian Field Naturalist* 103, 398-400.
- Howes, C.A. (1985) Pine marten. In: Yorkshire mammals (ed M. Delany). Yorkshire Mammal Group, York.
- IUCN (1992) Draft guidelines for re-introductions. *Re-introduction News* 4, 2-3.
- Jefferies, D.J., Wayre, P., Jessop, R.M. & Mitchell-Jones, A.J. (1986) Reinforcing the native otter *Lutra lutra* population in East Anglia: an analysis of the behaviour and range development of the first release group. *Mammal Review*, 16, 65-79.
- Kellert, S.R. (1985) Public perception of predators, particularly the wolf and coyote. *Biological Conservation* 31, 167-189.
- Kellert, S.R. (1992) Public attitudes toward bears and their conservation. *Proceedings of the Ninth International Bear Conference* (eds. J.J. Clear, C. Servheen & L.J. Lyon).
- Kruuk, H. & Conroy, J.W.H. (1987) Surveying otter (*Lutra lutra*) populations: a discussion of problems with spraints. *Biological Conservation*, 41, 179-183.
- Kruuk, H. & Conroy, J.W.H. (1991) Mortality of otters (*Lutra lutra*) in Shetland. *Journal of Applied Ecology* 28, 83-94.
- Labrid, M. (1986) La martre. Puceul. *Encyclopedie des Carnivores de France*. SFPEM.
- Langley, P.J.W. & Yalden, D.W. (1977) The decline of the rarer carnivores in Britain during the nineteenth century. *Mammal Review* 7, 95-116.
- Lankester, K., Apeldoorn, R. van, Meelis, E. & Verboom, J. (1991) Management perspectives for a population of the Eurasian badger (*Meles meles*) in a fragmented landscape. *Journal of Applied Ecology* 28, 561-573.
- Lawrence, M.J. & Brown, R.W. (1973) *Mammals of Britain and Ireland: their tracks, trails and signs*. Blandford Press, Poole, Dorset.
- Lockie, J.D. (1961) The food of the pine marten *Martes martes* in West Ross-shire, Scotland. *Proceedings of the Zoological Society of London* 136, 187-195.

- Lockie, J.D. (1964) The distribution and fluctuations of the pine marten, *Martes martes* (L.), in Scotland. *Journal of Animal Ecology*, 33, 349-356.
- Lockie, J.D. (1966) Territory in small carnivores. *Symposium of the Zoological Society of London* 18, 143-165.
- Millais, J.G. (1905) *The mammals of Great Britain and Ireland*. Longman, London.
- O'Sullivan, P.J. (1983) The distribution of the pine marten (*Martes martes*) in the Republic of Ireland. *Mammal Review*, 13, 39-44.
- Pulliainen, E. (1981) Food and feeding habits of the pine marten in Finnish forest Lapland in winter. *Proceedings of the Worldwide Furbear Conference* 1, 580-598.
- Pulliainen, E. (1982) Scent marking in the pine marten (*Martes martes*) in Finnish forest Lapland in winter. *Zeitschrift fur Saugetierkunde* 47, 91-99.
- Putman, R.J. (1986) *Grazing in temperate ecosystems - large herbivores and the ecology of the New Forest*. Croom Helm, London.
- Rackham, O. (1986) *The history of the countryside*. Dent, London.
- Reading, R.P. & Kellert, S.R. (1993) Attitudes toward a proposed reintroduction of black-footed ferrets (*Mustela nigripes*). *Conservation Biology* 7, 569-580.
- Senotier, J.L. (1992) Introductions et reintroductions de mammifères sauvages. XIV Colloque Francophone de Mammalogie de la S.F.E.P.M.
- Shaw, G. & Livingstone, J. (1994) The pine marten: its reintroduction and subsequent history in the Galloway Forest Park. *Transactions for the Dumfries and Galloway Natural History Society*. In press.
- Snyder, J.E. & Bissonett, J.A. (1987) Marten use of clear-cuttings and residual forest stands in western Newfoundland. *Canadian Journal of Zoology* 65, 169-174.
- Sokal, R.R. & Rohlf, F.J. (1981) *Biometry* (2nd edition). Freeman, New York.
- Soule, M.E. (1987) *Viable populations for conservation*. Cambridge University Press, Cambridge.
- Spencer, J.W. & Kirby, K.J. (1992) An inventory of ancient woodland for England and Wales. *Biological Conservation* 62, 77-93.
- Stanley Price, M.R. (1989) *Animal re-introduction: the Arabian oryx in Oman*. Cambridge University Press, Cambridge.
- Steventon, J.D. & Major, J.T. (1982) Marten use of habitat in a commercially clear-cut forest. *J. Wild. Manage.* 46, 175-182.
- Strickland, M.A. & Douglas, C.W. (1987) Marten. In: *Wild furbearer management and conservation in North America*. (ed. M. Novak, J.A. Baker, M.E. Obbard & B. Malloch). Ministry of Natural Resources, Ontario.
- Tapper, S.J. (1993) *Game heritage*. The Game Conservancy Trust, Fordingbridge, Hampshire.
- Thompson, H.V. & Worden, A.N. (1956) *The rabbit*. Collins, London.

- Varty, C. (1990) Pine marten in the Howgills and the northern dales. Yorkshire Naturalists' Union Bulletin, 13, 4-5.
- Velander, K.A. (1983) Pine marten survey of Scotland, England and Wales 1980-1982. The Vincent Wildlife Trust, London.
- Village, A. (1990) The kestrel. Poyser, London.
- White, P.C.L., Brown, J.A. & Harris, S. (1993) Badgers (*Meles meles*), cattle and bovine tuberculosis (*Mycobacterium bovis*): a hypothesis to explain the influence of habitat on the risk of disease transmission in southwest England. Proceedings of the Royal Society, London, B253, 277-284.
- Whitten, A.J. (1990) A proposed recovery programme for Britain's protected species. Nature Conservancy Council, CSD report No. 1089. NCC, Peterborough.
- Yalden, D.W. (1986) Opportunities for reintroducing British mammals. Mammal Review 16, 53-63.