PART IV SCHEMES FOR INDIVIDUAL SPECIES

INTRODUCTION

In this part of the report, we review the options for monitoring each species of mammal found in the UK in turn. These accounts should be read in conjunction with the accounts in MMR, because the latter present much important background information (based on wider consultation). Within the constraints of readability, we have tried to avoid repeating material already presented in MMR. We have treated species individually, except where common monitoring concerns, approaches and/or interests make this illogical (for example, squirrels). For each species, we note current status in the UK (including range, abundance and known population trend) and review any recent and ongoing monitoring work on that species. We then suggest objectives for the monitoring of each species, but we would stress that we supply these only as points for discussion and to put our subsequent remarks in context: decisions on the aims of monitoring (including the quantitative power required of survey schemes) should be made by consensus between mammal specialists and government.

We review the techniques potentially available to monitor each species (with particular consideration as to their suitability for use by volunteers) and then consider how these techniques can be combined into effective monitoring schemes. Where possible, we suggest more than one alternative scheme (or combination of schemes) and we review the proposals in MMR critically. For many species, our suggestions include the use of the multi-species schemes described in Part III, so the species accounts should be read in conjunction with the outlines of the relevant schemes provided there. We end each species account with a set of recommendations as to future priorities and practices for monitoring. Again, these should be taken as points for discussion which are subject to revision after input from government and mammal specialists.
1. **HEDGEHOG Erinaceus europaeus**

Native and widespread (probably introduced to Ireland). May have declined in last 50 years.

1.1 **RECENT AND ONGOING MONITORING WORK**

None.

1.2 **MONITORING OBJECTIVES**

Hedgehogs, though their numbers are probably influenced by interactions with Badgers and Foxes, are probably good indicators of the availability of ground invertebrates. They also resonate with the public, so are a valuable means of drawing wildlife issues to the attention of the public. For these reasons it is important to monitor them.

The objectives of monitoring should be to be able to detect population changes of 25% over 25 years, at the level of individual countries.

Intensive work may be needed on islands to which Hedgehogs have been (recently) introduced; our recommendations cover monitoring at the national scale.

1.3 **POTENTIAL MONITORING TECHNIQUES**

**Live-trapping** - Live-trapping of Hedgehogs is laborious, as the traps are large and the capture rate is low.

**Game Bags** - Game Bag data on Hedgehogs have been collected since 1961 by Game Conservancy Trust. We do not consider, however, that these provide reliable index data for Hedgehogs since this is a generalist species, subject to variation in effort of both control measures and recording, and since the change in its legal status consequent on The Wildlife and Countryside Act 1981 has led to fewer estates recording Hedgehog kills (Tapper 1992) - see Part III.A.2.

**Direct sightings** - Direct observations require many hours to be spent in the field per Hedgehog observed, though the frequency of observation is greater by night if a spotlight is used. Morris et al. (unpublished) worked in a high density population on Alderney and in habitats in which Hedgehogs were easily spotlighted - an airfield and a golf course. Even so, only two or three animals were detected per km walked. Dr Pat Morris (pers. comm.) estimates that 4-5 hours per site would be required to detect enough Hedgehogs for monitoring purposes.

**Field signs** - Hedgehog droppings are easily recognised, though are only conspicuous in short vegetation.

**Road-deaths** - Dead Hedgehogs are commonly seen on roads and are easily recognisable from a moving car. There have been various surveys of Hedgehog road-deaths and The Mammal Society is about to undertake analyses of extensive volunteer-based surveys conducted by Dr Pat Morris during 1991-1994.
1.4 POTENTIAL MONITORING SCHEMES

Spotlighting transects - MMR propose surveying at least 2000 sites on three consecutive nights every five years, each site covered by a 1km spotlighting transect. It would not be possible to recruit volunteers in the required numbers to conduct a survey, given the demanding nature of the work and the low success rate: given the results of Morris et al. (above), 0.5 animals/km is probably a generous guess of the likely mean sighting rate which suggests that even in three visits a high proportion of observers would see none at all, making it very unrewarding. To cover the sites professionally would take 400x3=1200 nights’ work, even if the sites were sufficiently clumped for five to be done each night, which equates to at least five man-years - or one man-year/year averaged over the cycle of five years. We do not believe this to be cost-effective, nor that modifications to this basic design could produce a substantially cheaper option.

Note that MMR suggest applying capture-mark-resighting techniques to the spotlighting data. The numbers seen per sampling occasion would be too low to give reliable results using this technique, judging from the results of Morris et al. (unpublished) in ideal conditions on Alderney.

Breeding Bird Survey - Hedgehogs appear to be encountered sufficiently often on BBS squares for this scheme to contribute usefully to their monitoring (see Part III.A.1).

Sign Transect Survey - These could provide useful information on Hedgehogs (see Part III.B.4).

Mammals on Roads - MMR recommend 2000 transects of 1km length, driven at least three times at weekly intervals, every five years. We believe Mammals on Roads transects would provide useful data, though would adopt a different protocol in detail (see Part III.B.5).

Mammals on Nature Reserves - We believe that Hedgehogs and their signs are commonly enough observed, and readily enough identified, for records on reserves to provide useful monitoring information (see Part III.B.6).

Garden Mammal Watch - Hedgehogs were the second most commonly recorded species in The Mammal Society’s Garden Mammal Survey, so Garden Mammal Watch could provide useful data (see Part III.B.7).

1.5 RECOMMENDATIONS

A combination of two more-or-less existing surveys (BBS and Garden Mammal Watch) and two others that could be mounted with relatively little further piloting (Mammals on Road and Mammals on Reserves) should provide sufficient information to detect major changes in Hedgehog numbers, though further quantitative analyses of the likely power of these schemes should be undertaken.
2. MOLE *Talpa europaea*

Native and widespread in Great Britain; absent from Ireland and most islands.

2.1 RECENT AND ONGOING MONITORING WORK

None. Moles are so difficult to count that there seem to have been no serious demographic studies.

2.2 MONITORING OBJECTIVES

We suggest that the Mole is probably a good indicator of soil invertebrate populations and that it should therefore be monitored throughout its British range. A decline in abundance (or in an index of abundance) of 25% over 25 years would be regarded as serious, so the monitoring programme should aim to detect this.

2.3 POTENTIAL MONITORING TECHNIQUES

**Direct sightings** - Moles are rarely seen on the surface, so this method is not useful.

**Road-deaths** - Haeck (1969) found that large numbers of young Moles were killed on roads in The Netherlands in June and July, as they dispersed from their natal territories. We believe that this species is too inconspicuous, however, for sightings of dead mammals to be included in the Mammals on Roads scheme (see Part III.B.5)

**Owl pellets** - Southern (1954) found that moles comprised 15% of the vertebrates taken by Tawny Owls *Strix aluco* in the midsummer dispersal period. However, they were much scarcer at other times of year. Barn Owls *Tyto alba* take Moles much less often, so such records are of little or no value for monitoring.

**Trapping** - Friesian live-traps have a fair success rate but are laborious to transport and set. In any case, both they and the various traps that kill Moles (and which are less laborious) need to be set in tunnels - which themselves provide an indication of the presence of Moles.

**Field signs (fresh tunnelling activity)** - New Mole hills are seen from midwinter onwards, as the animals repair damaged tunnels; since damage depends on soil structure and weather, so does the number of Mole hills. Surface tunnels are often conspicuous but are disproportionately dug in newly cultivated fields, very light soils and very shallow soils. Tunnelling activity is not always conspicuous in woodland, which is important Mole habitat. In addition to these habitat differences, tunnelling activity varies seasonally, not only in relation to winter weather damage but particularly in relation to the reproductive cycle: Moles burrow very actively in spring in the search for receptive females. Thus the observation of tunnelling activity is not a good indicator of Mole density. However, particularly if observations are made in the same places year after year and if habitat details are recorded, it can be used as a long-term monitoring index. The major caveat is its weather dependence. Given that there is no other easy way of monitoring Moles, we suggest that schemes based on observations of fresh tunnels should be used for monitoring; there is sufficient variation in weather from year to year for the potential impact of weather on the index to be examined as data accumulate, which will help in the interpretation of the index against the background of long-term climate change.
2.4 POTENTIAL MONITORING SCHEMES

Breeding Bird Survey, Winter Transects, Sign Transects, Mammals on Nature Reserves, Garden Mammal Watch - Observations of fresh Mole tunnels in these schemes are likely to provide a good long-term index of Mole numbers. For their own satisfaction, observers should also be allowed to include records of Moles seen dead or alive but these are unlikely to be numerous enough for monitoring purposes.

Mammals on Roads - We recommend against observers being asked to record Moles seen dead on the road but suggest that observations of fresh tunnelling activity beside the road might be trialed.

2.5 RECOMMENDATIONS

1) Moles should be monitored through a series of multi-species schemes, incorporating records not only of Moles directly observed (dead or alive) but also of fresh tunnelling. The schemes are:

   Breeding Bird Survey;
   Winter Transects;
   Sign Transects;
   Mammals on Nature Reserves;
   Garden Mammal Watch.

2) Observations of fresh tunnelling within sight of roads could be included in Mammals on Roads on a trial basis.
3. LESSER WHITE-TOOTHED SHREW *Crocidura suaveolens*

Introduced. Occurs on the Isles of Scilly and is believed to be widespread within most habitats offering adequate cover. There are few data available for this species, although it is believed that the population is currently stable.

3.1 RECENT AND ONGOING MONITORING

None.

3.2 MONITORING OBJECTIVES

Although populations of this species are thought to be stable, there is no empirical data either to support or to refute this claim. In view of this, periodic monitoring should be instigated initially with a view to producing baseline data against which future changes can be examined.

3.3 POTENTIAL MONITORING TECHNIQUES

**Live-trapping** - Lesser White-toothed Shrews can be caught using Longworth live-traps set in suitable habitat, ensuring that the treadle weight is set accordingly for an animal of its size (Churchfield 1990). A density of 10/hectare was reported in The Populations Review for populations in natural vegetation. This figure, coupled with home range sizes of 50-80m², suggests that a grid of traps covering 1ha should be used, with a 10m trap spacing. However, the suitability of this approach needs to be evaluated in the field across the range of habitats occupied by this species. The use of shoreline habitats further complicates the development of a standard method for trapping this species.

**Field signs (faeces)** - This species is the only shrew to occur on the Isles of Scilly, thus making it possible to use dropping boards or bait stations to collect faeces (see similar approach for Water Shrew - Abyes & Sargent 1997). This will provide information on the distribution of the species, together with a basic index of abundance. The suitability of this method would need to be evaluated during pilot fieldwork.

3.4 POTENTIAL MONITORING SCHEMES

Both the use of live-trapping and faeces counts at bait stations may potentially be used for monitoring this species. However, both need to be evaluated in the field and the two methods may be calibrated against each other during the initial stages of monitoring, with one being dropped if it were found not to be cost-effective. Populations of this species may fluctuate over the short-term and annual monitoring should be implemented for the first 10 years to examine short-term trends. If these prove to be absent then monitoring could take place periodically rather than annually, although this needs to be evaluated further.

The biggest difficulty with either of the two approaches is how to ensure that there is sufficient coverage of the diverse range of habitats the species uses. A suitable sampling design to cover all habitats needs to be discussed, possibly after some pilot work examining densities of the species in different habitats.
3.5 DEVELOPMENT AND VALIDATION STUDIES
A research study needs to be undertaken over a couple of field seasons in order to determine the habitat associations of this species. This information can then be used to establish a suitable sampling protocol for the use of either live-traps or faecal signs.

3.6 RECOMMENDATIONS

Pilot fieldwork needs to be carried out to establish the best way in which to monitor this species (live-trapping or faecal signs) and how to sample the diverse range of habitats used. Once this has been determined, monitoring should take place on an annual basis for the first 10 years and then periodically if short-term fluctuations prove to be insignificant.
4. RABBIT *Oryctolagus cuniculus*

Introduced. Widespread and abundant, with numbers highest in the east and south-east of England. Can cause damage to farming and forestry interests, although Rabbit grazing is beneficial in maintaining chalk grassland habitats.

4.1 RECENT AND ONGOING MONITORING

A full review of Rabbit surveys up to the early 1980s is provided by Trout *et al.* (1986).

**Forestry Commission Surveys** - Four surveys of Rabbits (and other wildlife) on Forestry Commission land have been carried out by the Wildlife Section of the Forestry Commission since 1968, at approximately five-year intervals. The data are sent in by foresters in response to a questionnaire and the accuracy of responses is ‘...inconsistent since the knowledge and interest of the respondents may vary.’ (Tee *et al.* 1985). However, since Rabbits and Rabbit damage are relatively straightforward to identify, the results for Rabbit are likely to be reliable.

**Environmental Change Network (ECN)** - MMR report that the ECN have selected the Rabbit as an indicator species to be monitored by winter pellet counts in selected sites, although this scheme has encountered statistical difficulties and only covers less than 20 sites.

**Game Conservancy National Game Bag Census** - The National Game Bag Census has recorded the numbers of Rabbits killed by keepers on many shooting estates since 1961. The general disadvantages of Game Bags are addressed in Part III.A.2. Additionally, the diverse ways in which Rabbits are controlled, together with changes over time in the favoured methods of control, make the Rabbit Game Bag data more difficult to interpret.

**British Association for Shooting and Conservation (BASC)** - Since 1980, a random sample of BASC members have recorded the number of Rabbits shot during the year. A basic index of abundance (number shot/km²) can be derived, although this contains a component of hunting effort, which would need to be separated before the data could be used to determine Rabbit abundance itself.

**Ministry of Agriculture, Fisheries and Food (MAFF) and Scottish Office Agriculture and Fisheries Department (SOAFD) Surveys** - Since 1969, MAFF has operated three consecutive types of Rabbit survey on farms. This work has been restricted to England and Wales and the different survey approaches are not directly comparable. Similar work has been carried out in Scotland (Kolb 1994) with surveys by SOAFD, formally DAFS, in 1969, 1970, 1973, 1974 and 1991. See Trout *et al.* (1986) [Table 1] for detail of the methods employed. Of the MAFF surveys, all three provide data of value for monitoring Rabbit distribution, but only the two most recent surveys allow calculation of Rabbit abundance. With the Scottish survey work, there was a problem in that there was a subjective element involved in judging the severity of infestation.

4.2 MONITORING OBJECTIVES

Rabbits should be monitored because of their economic importance (as pests of agriculture and forestry), their influence on vegetation structure and their importance to other bird and mammal species (Sumption & Flowerdew 1985). The widespread distribution of this species negates the need for distribution based monitoring, but monitoring of abundance would appear to be an important objective.
4.3 POTENTIAL MONITORING METHODS

**Game Bags** - Bags of Rabbits taken from estate records are prone to variation stemming from differences in the control measures employed. For this reason they are more difficult to interpret and less useful in a monitoring context. Rabbits may be taken by a number of different means, sometimes as part of a day's shoot, sometimes through ferreting, others through spotlight shooting or snaring. Some control measures may not be reported as part of the Game Bag records. However, a long term average trend has been produced from the Game Bag data by Tapper (1992) suggesting a recovery in the population following the increase in genetic resistance to myxomatosis. It has been established that the different methods of taking Rabbits have resulted in samples of different age and sex structure (Smith *et al.* 1995). These biases may have had an influence on the monitoring value of Game Bag data, as different methods for taking Rabbits have changed in popularity.

The British Association for Shooting and Conservation have information gathered between 1980-1983 on the number of Rabbits shot by a sample of its members. There is no information on whether this type of data will be gathered on a more regular basis using a more structured approach.

**Twilight counts** - Counts taking place at dawn and dusk reveal about 15-20% of the population during winter and 40-60% of the population during the summer. Trout & Tittensor (1989) note that at least three counts are required to attain sufficient accuracy.

**Spotlighting** - Like hares, it is possible to detect Rabbits at night by using a spotlight to produce eyeshine. Barnes & Tapper (1985) developed a method to count Brown Hares using this approach and this could be re-evaluated to allow the production of population estimates for Rabbits. The method was found to be most appropriate (in the case of Brown Hares) when applied to the assessment of large differences between Brown Hare populations in extensive studies.

**Field signs (warren entrances)** - The number of active warren entrances has been demonstrated by some authors to be related to the number of Rabbits using the warren (Parer & Wood 1986). However, this relationship '...is likely to be highly variable, and in high-density populations the relationship may be non-linear..' (Parer & Wood 1986). In some habitats entrances will be more difficult to find than others, while in a few instances Rabbits may not use burrows at all. Collectively this suggests that the use of warren entrance counts may be of little value for long-term monitoring, even though it has the advantage that it is quick and relatively easy to record such features.

**Field signs (pellet counts)** - Counts of faecal pellets may be used to determine the presence of Rabbits at a site, although there may be some confusion with those produced by Brown or Mountain Hares. The density of Rabbits may be calculated from counting pellets within a specified area. This approach has been widely used for deer (Bennett *et al.* 1940; Bailey & Putman 1981) and potential problems with the method have been reviewed (see Neff 1968). The technique has been used for Rabbits (Taylor & Williams 1956; Trout & Tittensor 1982; MAFF 1982; Wood 1988).
While consistent relationships between Rabbit density and pellet density have been found within some sites (overseas), or across sites with similar characteristics, Angerbjorn (1983) points out [from work on hares] that separate factors are necessary to convert pellet density to hare density for habitats which differ substantially. While it may not be possible to compare Rabbit densities between habitats, it should be possible to monitor trends in abundance within sites, so long as the same monitoring sites are used year-on-year. Variability in pellet production and pellet decay rates may result from a number of factors. Production rates may be influenced by changes in the quality of vegetation (Arnold and Reynolds 1943), which in turn may be related to season (Lockley 1962) or climatic differences between years. Consideration should be given to these effects if a monitoring protocol based on pellet counts is to be implemented. The successes of the MAFF scheme and ongoing work by Roger Trout suggest that Rabbit abundance may be monitored through the use of pellet counts along transects.

### 4.4 POTENTIAL MONITORING SCHEMES

**Garden Mammal Watch** - Rabbit may be recorded as part of the proposed Garden Mammal Watch scheme (see Part III.B.7), although it is not clear how often Rabbits will be recorded in gardens and to what extent those that are recorded are representative of the population in the wider countryside.

**Mammals on Roads** - Rabbits are likely to feature quite prominently in those species seen dead on the roads. However, encounters with dead Rabbits may be too frequent to be of value to the index approach outlined in Part III.B.5. To overcome the problem of a lack of stability in the Rabbit population during the summer months, road-transects would need to be covered in the winter, something that may be impractical.

**Breeding Bird Survey** - Rabbits were reported from about 70% of those transects for which BBS mammal data were received, suggesting that the BBS approach may be suitable for this species. However, the BBS count data need evaluation and the BBS presence/absence data needs evaluation against other schemes.

**Sign Transects** - (see Part III.B.4) Rabbits can be recorded through a field sign survey providing a simple index of abundance without the need to determine a relationship between pellet density and Rabbit density. This approach should be carried out during the winter months when the Rabbit population is more stable. It is not thought that Game Bags, BBS transects or other datasets could be used successfully for the monitoring purposes outlined.

### 4.5 DEVELOPMENT AND VALIDATION OF STUDIES

Work should be carried out to determine the relationships between Rabbit density and pellet density for a range of regions and habitats. This can then be used to calibrate data from the sign transects.
4.6 RECOMMENDATIONS

1) The abundance of Rabbits at a series of fieldsites should be determined annually through Sign Transects (Part III.B.4).

2) Ancillary data should be gathered through Garden Mammal Watch (Part III.B.7) and Mammals on Roads (Part III.B.5) schemes. The value of such data should be evaluated against that derived from sign transects. Data from BBS can also be fed in to the monitoring programme.
5. HARES

MOUNTAIN HARE *Lepus timidus*: native to Britain and Ireland, southern British populations introduced; in Britain, restricted to Scottish uplands, the Isle of Man and the Peak District but locally common, widespread in Ireland and found in many habitats; stable but vulnerable, especially with respect to global warming.

BROWN HARE *Lepus europaeus*: introduced to Britain in Roman times or earlier, introduced to Ireland in the 19th century; common and widespread in Britain but abundance variable, scarce and localised in Ireland; has declined considerably but now perhaps stable.

5.1 RECENT AND ONGOING MONITORING WORK

National Brown Hare Survey - A winter transect survey, using distance sampling, of 738 1km squares forming a random sample stratified by ITE Landscape Region, conducted in 1991-1993 (Hutchings & Harris 1996). Consideration of more than one winter minimized the impact of inter-annual fluctuations in numbers on population estimations. A statistically sound and unbiased survey giving a baseline national population estimate of 817,520±137,521 Brown Hares, to which future survey results can be compared. The survey has been repeated in 1997-1999 and preliminary analysis suggests that Brown Hare numbers have fallen slightly in arable and pastoral habitats, despite the presence of set-aside land which was expected to benefit the species (S. Harris, pers. comm.).

National Game Bag Census - Long-term data (1961 onwards) on Brown and Mountain Hare shooting bags taken from keepered estates in Britain.

Game Conservancy Trust Spring Census - Twilight counts of Brown Hare numbers at 34 different sites in Britain since 1989.


The Mammal Society - A national questionnaire survey for Brown Hares aimed at past trends and current status. Analysis is incomplete as yet, but county-specific trends tend to have shown increases between the 1960s and 1970s and declines between the 1980s and 1990s.

Sorby Natural History Society - An annual, set winter walk of c. 20km: effectively an annual transect survey for Mountain Hares in one part of the Peak District (east of the Pennines) (D.W. Yalden, pers. comm.). Typically, 60-100 Mountain Hares are recorded.

Derbyshire Wildlife Trust - Another annual winter walk on which Mountain Hares are counted, this one in the Western Pennines and c. 10km long. Typically, 30-50 Mountain Hares are recorded (D.W. Yalden, pers. comm.).

5.2 MONITORING OBJECTIVES

As with other quarry species, it may be important to monitor hares both to determine their conservation status and to indicate whether current hunting pressures are sustainable. Under the
JNCC Brown Hare Species Action Plan, two points for *Future research and monitoring* are relevant to objectives of monitoring for the species:

5.5.1 Promote further research to assess the effects of different agricultural practices (e.g. crops planted, cutting dates and cutting methods) on Brown Hare populations.

5.5.3 Repeat the National Brown Hare Survey at regular intervals.

The second point clearly represents one complete option for the monitoring of Brown Hares in the long term (see below). While not necessary for monitoring changes in numbers, detailed habitat recording during survey work could allow studies to be conducted which contribute to the first point. Hare numbers are known to be very variable, so annual monitoring is needed for the two species: surveys at long intervals could give false impressions of long-term trends.

Although Mountain Hares are native and both rarer and more vulnerable than Brown Hares, no Species Action Plan has been prepared for the species. It would seem logical that the monitoring of Mountain Hare populations should be given a higher priority than that of Brown Hare populations.

Special consideration needs to be given to Mountain Hares in Northern Ireland, where they occur in lowland areas and may interact with Brown Hares: data collection and/or interpretation would therefore have to be different.

By analogy with current monitoring practices for birds, the detection of trends leading to population changes of 25% over 25 years could be taken as the target for hare monitoring.

### 5.3 POTENTIAL MONITORING TECHNIQUES

**Line transect counts** - Transect methods allow populations to be sampled quickly and efficiently using standardised methods. Recording in distance bands allows density to be estimated. Habitat recording along transects can also be standardised. For hares, counts would best be made between October and January when vegetation is low and detection rates are high (although the animals are still visible at other times) and before most hare shooting (which will increase the variance of counts) occurs (Harris, in press). Timing is less critical if simple counts are used instead of distance sampling. Late spring/early summer counts (as in the BBS) are likely to overestimate numbers of breeding adults because the year’s juveniles can have been born as early as January and be difficult to distinguish from adults. Such counts could then be heavily affected by variations in productivity from year to year, obscuring variations in adult abundance. Daylight counting probably underestimates true densities because hares are less active than at twilight or after dark.

**Standard winter walks** - Effectively surveyor-designated transect routes, annual or twice-annual winter walks of (say) 2-10km with standardised mammal and habitat recording methods could be an efficient way of managing volunteer surveyor input. Data collection would best be simple counts, rather than distance sampling. Such a method is used by the Sorby Natural History Society and Derbyshire Wildlife Trust to monitor Mountain Hares and it may be particularly suitable for this species and upland habitats. A disadvantage is the lack of randomisation of
transect routes with respect to habitat, but this has no necessary serious effect on the method’s potential for detecting population changes.

**Direct counts (total or sample, daylight, twilight or spotlight)** - Direct counts aim to account for all individuals within an area or a sample of an area. Considerations for the timing of counts are the same as for line transects. While direct counts measure true density if they are accurate, they also require more intensive coverage of an area than do transects, so any gains may be outweighed by the extra time taken. Spotlight counts are very specialised, difficult to standardise and best analysed only on a site-specific basis (S. Harris, pers. comm.).

**Drive counts and dragline counts** - Total populations can also be counted by driving with beaters or dogs or by using draglines. However, as with direct counting, considerable effort is required: in these cases, teams of individuals for each survey plot.

**Capture-Mark-Recapture** - Hares can be caught in nets and tagged, allowing population sizes to be estimated by CMR. However, netting is difficult, costly and time-consuming.

**Hunting and Game Bag records** - Long time series of historical game bag and hunting records exist and these data are likely to continue to be collected. These data can therefore at least provide a valuable historical context for future survey data. However, hunting and bag record data are subject to important biases which severely limit their potential as a front line monitoring method. First, they are derived mostly from estates and areas that are managed for hares, (supporting (often artificially) high hare densities), and so are unlikely to be representative of the wider countryside and of any areas where densities are low or falling. Second, they will depend critically on the hunting effort (which includes method (driven shooting versus culling with rifles) and gun and shooter efficiency, as well as man-days) and, which is rarely recorded. Third, numbers of Brown Hares are regularly trapped in high density areas and moved to restock other areas where high densities are required by coursing interests, thus weakening any relationships there might have been between game bags and the environment. Fourth, no counts are returned by estates where shooting does not occur in a given year because of low population levels, so population indices based on national game bags will always be biased upwards. Tapper & Parsons (1984) considered that estates will generally manage annual bags to be a fixed proportion of the Brown Hare population (around 40%), but this has been questioned (Hutchings & Harris 1996) and is also unlikely to be true for the less managed Mountain Hare. The issues of representativeness will apply equally to other count schemes run by hunting interests.

**Counts by beaglers** - Numbers of hares seen by beagling packs are collated by the Game Conservancy. As well as problems with representativeness as discussed above, beaglers choose areas for hunting, and therefore sampling, to have an optimum density which is neither too low nor so high that dogs are confused (S. Harris, pers. comm.).

**Field signs** - Field signs are difficult to distinguish between species and can also be confused with those of Rabbits. Such indirect methods will inevitably be less accurate than visual count methods for open habitat species as visible as hares, so are not preferable.

**Questionnaire surveys** - Simple questionnaires have the advantage that they can reach much larger samples of people, but data quality will be variable and subjectivity is a problem. Again, this is not a priority method for species like hares which can easily be censused in other ways.
5.4 POTENTIAL MONITORING SCHEMES

All of the following schemes would provide information on changes in abundance and in range.

Repeats of the National Brown Hare Survey - This is the approach recommended by the Species Action Plan for Brown Hare. Repetition need not be at fixed intervals, but could occur as a response to external stimuli whenever it were considered necessary. The methods used are strong, leading to the collection of high quality density and habitat information. However, the scale and intensity of the National Brown Hare Survey is such that it is unlikely to be economically feasible for it to be repeated annually (and it was never designed for such a purpose, running over several winters).

MMR recommended approach: Hare Survey transect methods applied within the MaMoNet grid - This approach describes a scheme which is more than three times the size of the National Brown Hare Survey (2,700 sites). The survey would therefore be more expensive (at least if conducted in isolation) and still more difficult to repeat annually than the Hare Survey. Such a sample size is also much larger than would be required to obtain enough count data for the effective monitoring of Brown Hares, so would not be cost-effective (S. Harris, pers. comm.).

Breeding Bird Survey - The BBS transect approach is described in detail in Part III.A.1. It has several disadvantages specific to hare monitoring, primarily because of the timing of the survey: counts in spring and early summer will be subject to potentially large fluctuations as a result of both variable annual productivity and changes in shooting pressure. Despite these problems, the BBS may provide useful and reliable information on changes in (especially) Brown Hare numbers, as a result of its wide geographical coverage and large sample size, and the ease with which the animals can be seen by BBS surveyors (see Part III.A.1). The extent and seriousness of any problems with the BBS method would need to be investigated before the survey were adopted as a central contributor to UK hare monitoring. Calibration against a full or trial Winter Transect Survey (Part III.B.1) ought to supply the necessary information.

Winter Transect Survey incorporating upland standard walks - Mid- to late winter is likely to be the best time of year to survey most mammals using visual methods, so a multi-species, standardised winter transect survey could be a widely applicable and useful method (see Part III.B.1). Hares would be key “flagship” species for such a survey scheme and would perhaps be the group for which we would expect the highest quality data to be collected. Carefully chosen squares offering a partial repeat of the National Brown Hare Survey would allow the linking of future data to an historical context. The optimal timing for hare monitoring might be different to that for other species and compromise may be required. Upland areas present special problems because of weather and access, so the option of surveyor-designated standard walks would be a useful one in such areas. The organisation of such a scheme would most efficiently be done as an offshoot of the more formal Winter Transect Survey.
5.5 RECOMMENDATIONS

1) We suggest that a combination of BBS summer transect data and Winter Transect Survey data should form the core national monitoring schemes for Brown Hare. BBS methods are not ideal for mammals (see Section III.A.1) but the sample size of survey sites is large (over 2000) and running a Winter Transect Survey in parallel should identify any major biases and perhaps supply annual correction factors. At least, pilot winter transect data from the same squares as sampled by BBS will be required to calibrate BBS data. The design of a Winter Transect Survey is dealt with in detail elsewhere (Section III.B.1), but the options include a standard walk approach and more standardised transects.

2) Multi-species transect surveys may be sufficient for the monitoring of Mountain Hare populations, but their geographical distributions in Britain are likely to mean that sample sizes will be small as a result of local volunteer densities. The importance of Mountain Hare as a vulnerable, native species means that effective monitoring could be a priority. We therefore suggest that the standard winter walk approach be developed to sample areas representative of the whole of the species’ range, building on the Sorby Natural History Society and Derbyshire Wildlife Trust walks.

3) To provide historical context, attempts should also be made to calibrate Game Bag data against BBS and Winter Transect Survey data. A key issue is the relationship between data from shooting estates and from the wider countryside, which should be investigated. However, it is important that the possibility that Game Bags will provide no useful information at all is acknowledged prior to any attempts at calibration.
6. SQUIRRELS

**RED SQUIRREL *Sciurus vulgaris***: native to Britain but probably introduced to Ireland; locally common in Scotland, scarce and localised (some populations re-introduced) in England and Wales but widespread in Ireland; declining.

**GREY SQUIRREL *S. carolinensis***: introduced; common throughout most of England and Wales and central Scotland, more restricted than Red in Ireland; increasing and spreading.

6.1 RECENT AND ONGOING MONITORING WORK

**NPI Red Alert North West** - A developing survey of Red Squirrels in north-west England. Sightings data have been solicited from the public, volunteers and foresters since 1995 and have been useful in documenting the spread of Greys. Visual transect methods using volunteers are in development, working from three repeat surveys in each of spring and autumn. Basic volunteer training is included to allow the use of distance-sampling methods and to promote consistency. Hair tube methods are also in development for areas where visual transects are less useful (small and dense woodlands), but will require more professional input than the transect approach. A transect-based hair tube survey of squirrel distribution in Cumbria is currently being written up.

**Biological Recording in Scotland Campaign (BRISC): Scottish Red and Grey Squirrel Survey** - A current survey of Scottish squirrels which began in 1994. BRISC collect records opportunistically or from sightings-based questionnaires. Sightings data are collected centrally and stored in a database administered by SNH. BRISC have also organised specific surveys in known Red Squirrel areas, visiting different sites on different occasions. Following recommendations from SNH, the surveys consist of parallel transects (100m apart) walked by teams of volunteers looking for Red and Grey Squirrels themselves (not field signs) (A.-M. Smout, pers. comm.). The lack of repeat visits under the current survey design clearly limits this survey to the generation of “snapshots” at present.

**Forestry Commission** - Records of presence and absence at the 10km square scale on Forest Enterprise land, together with data on the extent/severity of tree damage and the amount of Grey Squirrel control practised, for 1960-1994. This monitoring has since ceased, to be replaced with a scheme to monitor abundance of both species as well as presence/absence in the context of the Red Squirrel Species Action Plan (see below). The protocol for the new scheme has yet to be finalised, but recommended methods will include time-area counts, hair tube surveys and line transects looking for feeding signs. It is intended that data collection will be volunteer-based and managed by local squirrel groups and wildlife trusts.

**Institute of Terrestrial Ecology** - Annual monitoring of Red and Grey Squirrel abundance in a small number of woods.

**Northern Ireland Distribution Survey** - Presence/absence and crude abundance data from sightings, field signs and interviews organised by the Ulster Wildlife Trust and the Forest Service of the Department of Agriculture for Northern Ireland in 1993.

**Isle of Wight Red Squirrel Survey** - A standardised presence/absence survey using field signs, conducted in all woods of more than 1ha.
Encroachment by Greys into Red Squirrel habitat - Studies at the Universities of Oxford and Newcastle of selected populations where the species are interacting.

6.2 MONITORING OBJECTIVES

In the Future research and monitoring section of the Red Squirrel Biodiversity Action Plan, the following point defines the objectives of monitoring for the species:

5.5.2 Establish a survey method and Squirrel Monitoring Scheme to ascertain population levels, identify key sites and monitor range and population of Greys.

This appears to specify a need for the monitoring of the range and abundance of both Red and Grey Squirrels in the UK. However, Greys may not be considered the object of conservation interest and so could be given a lower priority, i.e. monitoring need not be able to identify such a small change in distribution or abundance: they are also not protected, so can be culled locally if it is deemed necessary for control purposes. Damage to timber and woodland biotopes as well as the prevention of the establishment of new woodlands are issues here (S. Gibson, pers. comm.). Intensive monitoring might best be focused on areas where Red and Grey populations are interacting.

6.3 POTENTIAL MONITORING TECHNIQUES

Visual transect counts - Transect methods allow populations to be sampled quickly and efficiently using standardised methods. Recording in distance bands allows density to be estimated in theory, but in practice problems with detectability and with the estimation of distances in a three-dimensional habitat invalidate the results (S. Harris, pers. comm.). Habitat recording along transects can also be standardised. For squirrels, differential detection rates with respect to habitat pose particular problems, such as in deciduous versus coniferous woods, but sampling or statistical controls could account for such differences in the indexing of population change (density estimates would be biased). Counts would be best made in early morning and, in early spring, would benefit from better visibility in deciduous habitats. Some observer training may be required to assist species identification because well-known features such as pelage colour and the presence of ear tufts are not reliable in all seasons. Early spring transects would maximise detection rates; spring/summer counts such as practised under the Breeding Bird Survey will suffer from variation due to inter-annual differences in productivity and detection problems due to vegetation growth (especially in deciduous woods) (see Part III.A.1). In general, visual transects are likely to be more reliable for Grey than for Red Squirrels: behaviour and population density mean that a higher proportion of the population will be encountered more frequently (S. Harris, pers. comm.).

Direct counts (total or sample) - Direct counts aim to account for all individuals within an area or a sample of an area. Variations in detectability are accordingly more of a problem than with transect counts. In addition, while direct counts measure true density if they are accurate, they also require more intensive coverage of an area than do transects, so any gains may be outweighed by the extra time taken. Standardised time-area observation counts (Gurnell & Pepper 1994) fall into this category.
**Capture-Mark-Recapture (CMR)** - Baited cage traps, checked twice daily, can be used to catch squirrels and individual ear tags or combinations of fur tags to mark them (Gurnell & Pepper 1994). Standard statistical methods then allow the estimation of population size. The disadvantages with this method are that it is labour-intensive and requires specialised equipment and training and (for Red Squirrels) government licences.

**Field signs (cone cores)** - Field signs such as pine cone cores can be searched for using standardised methods and then related to density, but species identification is a problem. Pine cone cores can be counted along standard transects which are raked clean after each transect count, giving information on squirrel habitat use, activity and perhaps abundance (although this requires verification) (Gurnell & Pepper 1994). The most important problem with this method is that cone cores left by Red and Grey Squirrels cannot be distinguished.

**Field signs (winter drey counts)** - Counts of drey visible along line transects in February and March can be used to estimate density, based on published studies (Don 1985; Wauters & Dhondt 1988; Gurnell & Pepper 1994). Drey counting is most effectively done by teams of observers walking parallel transects 25m apart and it is important that dreys in current use are distinguished from derelicts and birds’ nests (Gurnell & Pepper 1994): these factors make this technique less suitable for use by volunteers. It seems likely that relationships between drey and squirrel density will vary with habitat, as will drey detectability: this would bias estimates of squirrel density but would not necessarily affect a population index. Dreys will be difficult to identify reliably to species level, so would only be useful for monitoring in areas where the two species do not co-occur.

**Hair tubes** - Plastic tubes of 75mm diameter with adhesive tape placed just inside the entrance(s), fixed to branches at least 2m above the ground and baited, can be used to collect samples of hair which can then be identified to species level in the laboratory where necessary (i.e. where more than one species occurs in the study area) (Gurnell & Pepper 1994, Garson & Lurz 1998). Hair identification is best done by negative staining: Red Squirrel hair features a longitudinal groove in which dye collects (Dagnall et al. 1995). The presentation of hair tubes according to a standardised protocol (for fixed periods of time at a fixed density along a transect or in a sample plot) can be used to estimate density or to provide an index of abundance as well as indicating species presence (the adhesive tape with attached hair samples is removed at regular intervals). This method provides a useful intermediate between visual surveys and CMR: it is likely to be less biased than a visual approach, does not require licensing and is less labour-intensive than CMR. It should be noted that hair tubes measure activity rather than numbers of animals per se, so detection rates are likely to be related non-linearly to abundance.

**Road-deaths** - Standardised records of squirrel corpses on roads could be used as a monitoring tool, but information on abundance (at least) would depend critically on “sampling effort”, i.e. traffic density and distances travelled in searching for corpses (see Part III.B.3).

**Garden Mammal Watch** - Squirrels are popular, visible animals in gardens, so reliable, simple presence/absence or abundance data should be readily obtainable from volunteers. This could be a low-cost method for the monitoring of Grey Squirrel populations and the species would be a key one in our proposed Garden Mammal Watch (Part III.B.5). Garden sightings may also provide information on changes in the ranges of each squirrel species.
Reports of presence/absence - Simple reports of squirrel presence or absence from well-watched and well-defined areas such as nature reserves or Forestry Commission woodlands might give the most reliable and earliest warnings of changes in the range boundaries of both species. Such a scheme would involve a regular collation of opportunistic sightings made by individuals such as nature reserve wardens during the course of their normal activities and is discussed in Part III.B.4.

6.4 POTENTIAL MONITORING SCHEMES

MMR Recommended Approach - Within the national MaMoNet QQ grid of 10km squares, MMR recommend that each selected 1km square be surveyed for dreys in winter, using a distance-sampling “crenellated transect” approach. Where both species occur (and in a buffer zone around these areas), the base method would be supplemented with direct counts in which individual squirrels are identified. Red Squirrel-only areas would be surveyed every three years, Grey-only areas every six years and areas where the species mix would form annually surveyed Focus Zones. The weaknesses of this monitoring package are that the principal method, drey counting, is far from ideal and possibly seriously biased as well as perhaps being labour-intensive (see above). There are also doubts about direct counts, but they may represent the best method for volunteer or non-expert involvement in squirrel surveys.

Combined, complementary surveys - Squirrels are difficult to survey accurately using simple methods. Our philosophy here is therefore that a number of complementary, simple and (individually) non-ideal multi-species surveys can be combined to give an overall picture of squirrel populations. Specifically, the Breeding Bird Survey (Part III.A.1) can potentially contribute considerable information on Grey Squirrels (in particular), a Winter Transect Survey would probably provide higher sighting rates and therefore more information still (see Part III.B.1), a Garden Mammal Watch would give information on suburban populations (see Part III.B.5), road-deaths would give information on distribution and perhaps abundance (see Part III.B.3), Mammals on Nature Reserves would give reliable information on changes in range, and Sign Transects could also contribute (see Part III.B.2). The relative importance of each of these schemes will depend on the uptake of each by volunteers and then on the detection rates found in practice. These schemes would be supplemented by more intensive work using hair tubes in and around the areas where the two species’ ranges overlap. This work would best be done by professionals and/or trained amateur enthusiasts. Existing Red Squirrel monitoring schemes such as Red Alert North-West and the Isle of Wight Survey may already meet the requirements of this work or be easily adapted to it. In terms of organisation, this approach would require the establishment of the various new schemes listed above and annual central collation of the information collected. Separate surveys could be conducted by different organisations but it would be most efficient if they were run by the same body, which would then also collate information annually.

Current schemes directed towards Red Squirrel - A subset of our recommended methods for multi-species monitoring, sufficient to detect large changes in abundance or distribution (perhaps just the BBS), may be enough to monitor squirrels in conjunction with existing Red Squirrel monitoring. Threatened populations of Red Squirrels (especially) are often monitored already: additional work might only have to involve central collation and evaluation of the existing schemes. This would require guaranteed repeat survey or continuation funds for schemes such as Red Alert North-West, the Isle of Wight Red Squirrel Survey and the BRISC Red and Grey
Squirrel Survey (perhaps with a standardisation of methods and expanded coverage where necessary). Funding would be required for the central collation of information from the various sources of monitoring data: within a dedicated mammal research organisation, this could be achieved with an annual input of no more than one or two months of staff time.

6.5 RECOMMENDATIONS

1) Consensus on the precise requirements of a monitoring programme for Red and Grey Squirrels must first be established, i.e. it must be decided whether Grey Squirrel populations are of intrinsic interest or of interest only in terms of their impacts on Reds. Detection of a 10% decline over 10 years may be required for Red Squirrels (S. Gibson, pers. comm.). Decisions about monitoring should be made in consultation with the UK Red Squirrel group and with respect to the Red Squirrel Biodiversity Action Plan. Patterns of interaction also differ between Britain and Northern Ireland, so different strategies may need to be adopted.

2) Our proposed multi-species monitoring schemes would all contribute some information on Grey Squirrels, so a combination of them (managed centrally by a national organisation) gives a potentially valuable approach for monitoring this species.

3) If monitoring the species is deemed to be important, the existing monitoring schemes for Red Squirrels should be promoted and future funding guaranteed, perhaps on the condition that the methods used are standardised as much as possible. In general, it should be ensured that all monitoring schemes adhere to controlled protocols and a statistically sound sampling regime.

4) Given that the areas of expansion of Grey Squirrels and of contractions of Reds are of paramount importance for monitoring, professional hair tube studies of areas of interaction between Reds and Greys should be established where they do not already exist. These would best be done or coordinated by a national mammal monitoring body. Such work should require no more than one staff-year annually, but might most efficiently be divided between locally-based fieldworkers (who could be employed on short contracts or be drawn from the staffs of county Wildlife Trusts or the country agencies), together with a central collation effort.

5) Careful consideration of the integration of new volunteer-based schemes such as the incipient Forestry Commission survey with established schemes such as Red Alert North-West is needed. It would be desirable for different schemes to use the same methods and to be run in collaboration with one another, at least at a committee level. It is imperative that different surveys do not compete for volunteers.
7. ORKNEY VOLE *Microtus arvalis*

Introduced. Within the United Kingdom the species is found on only six of the Orkney islands (and Guernsey). The population has almost certainly declined as a result of substantial changes in land use.

7.1 RECENT AND ONGOING MONITORING WORK

_Aberdeen University_ - Work has been carried out by Aberdeen University for a number of years investigating Orkney Vole populations and interactions with their predators (Gorman & Reynolds 1993).

7.2 MONITORING OBJECTIVES

The Orkney Vole is the only diurnally active rodent on the Orkneys and it is therefore extremely important as a potential prey item for Hen Harrier *Circus cyaneus*, Kestrel *Falco tinnunculus* and Short-eared Owl *Asio flammeus*. Recent changes to the landscape of the Orkneys have almost certainly reduced the population of Orkney Voles and an assessment of the current population size is urgently needed. Gorman & Reynolds (1993) provide density estimates for a range of habitat types and these may contribute to assessment of future monitoring requirements. Monitoring needs to be carried out on an annual basis to account for short-term cyclic behaviour in population trends. These should also be taken into account when the baseline population estimates are calculated by running fieldwork over several seasons.

7.3 POTENTIAL MONITORING METHODS

**Live-trapping** - Orkney Voles can be readily monitored within favoured habitats, notably along fence lines (Martyn Gorman, pers. comm.), using Longworth live-traps. The Capture-Mark-Recapture (CMR) method and its inherent biases have been discussed in depth by MMR and by Flowerdew (1976).

**Field Signs** - The value of field signs to the monitoring of Orkney Vole populations needs to be evaluated. The likely dramatic changes in density with the stage of the vole cycle may mean that such methods may be readily applied to determine short-term changes of large magnitude, but be less suitable for determining more subtle longer term trends.

7.4 DEVELOPMENT AND VALIDATION STUDIES

A formal trapping protocol should be established following discussions with Martyn Gorman and colleagues at the University of Aberdeen.

7.5 POTENTIAL MONITORING SCHEMES

A live-trapping approach is recommended for the monitoring of Orkney Vole populations on an annual basis. Following an examination of densities within different habitats and discussions with Martyn Gorman, a series of study sites should be selected reflecting the distribution of the species across habitats in the Orkneys. Each site should be trapped using a traline of Longworth live-traps (see Development and Validation of Studies) twice a year (during trough and peak months of the annual cycle) to provide measures of density. Each site should be trapped for five days and is likely to involve 80-100 traps with a single observer covering four sites at a time. With a six-week trapping window for each of the two trapping periods this would allow four sites...
to be covered each week, or 24 sites in total, representing c.60 working days a year. Gorman & Reynolds (1993) covered 14 different habitats on the mainland with each habitat trapped for five days, four times a year. Work could be undertaken by professional fieldworkers from the University of Aberdeen or by volunteers co-ordinated by a single professional. The Orkney Field Club may be a suitable organisation to approach regarding volunteer input.

7.6 RECOMMENDATIONS

Orkney Vole populations should be monitored at a core of 20-30 sites within the range of habitats occupied by the species using a live-trapping approach and CMR methods. The exact trapping protocol should be determined through discussions with researchers at the University of Aberdeen. Monitoring must take place on an annual basis to allow for short-term fluctuations in abundance resulting from the cyclic behaviour of this species. Volunteer involvement (with a professional co-ordinator) could perhaps be mediated through the Orkney Field Club.
8. WATER VOLE *Arvicola terrestris*

Native. Widespread on mainland, but absent from most of Northern and Highland Scotland and from most islands. Dramatic and widespread decline, both in terms of numbers and distribution.

8.1 RECENT AND ONGOING MONITORING WORK

**Nature Conservancy Council Enquiry** - An enquiry into the changing status of the Water Vole was carried out using data from county mammal reports, supplemented by questionnaire responses from participants in the BTO's *Waterways Bird Survey*. The analysis suggested a long-term decline in the Water Vole population linked to the pollution of rivers by organochlorines from the 1950s and the spread of introduced American Mink from the 1960s (Jefferies *et al.* 1989). Although not 'monitoring' per se, this work does illustrate the possibility of collecting useful data from observers involved in other survey work within riverine habitats.

**Vincent Wildlife Trust Survey 1989/90** - Baseline survey work was carried out by a single professional recorder using a systematic search of pre-selected sites chosen from within a grid of 10-km squares. This was supported by a search of sites for which there was historical evidence of the species. Of the 2,970 sites covered, 47.7% had signs of Water Voles (Strachan & Jefferies 1993; Morris *et al.* 1998). Reanalysis of the data by Morris *et al.* (1998) provided a population estimate of 7,236,000 individuals, although the confidence intervals for this estimate are very wide. It should be noted that the national survey fieldwork was carried out throughout the year. Therefore, the low number of latrines reported in some areas may be a consequence of the timing of fieldwork rather than a reflection of population size. Latrine use varies seasonally with little or no above ground latrine formation in the winter. This reduces the spatial quality of this component of the dataset, introducing bias into conclusions drawn about Water Vole distribution across catchments.

**Vincent Wildlife Trust Survey 1997/98** - A repeat of the 1989/90 survey, again using professional recorders working at the same sites and using the original methodology. Field sites were revisited during the same season as for the previous survey, thus removing the bias associated with sampling date and allowing a comparison to be made between the two datasets. The data are currently being analysed and a report is due to be published at the end of 1999. When the results are published it will be possible to be much clearer about the future monitoring strategy for this species.

**WildCRU** - An ongoing study using *River Corridor Survey* methodology to record Water Vole distribution within seven river catchments (Bure, Isle of Sheppey, Isle of Wight, Itchen, Teifi, Thames, Tyne). See MMR for full description of methods. Also within the MMR is a detailed assessment of possible sampling regimes based on this approach and their application to a national monitoring programme for Water Voles.

**Aberdeen University** - Four projects concentrated within the River Don catchment initiated from 1995 onwards. The projects examine the behavioural ecology, conservation, metapopulation dynamics and phylo-geography of Water Vole populations. As with the WildCRU work, this project can potentially provide detailed information on Water Vole populations within a specific catchment and could contribute to an examination of suitable recording methods.
Environment Agency - The Environment Agency's River Habitat Survey documents the presence of Water Voles in conjunction with the collation of data on habitat and river features. The detailed nature of the survey, coupled with the large number of sample sites, could provide useful information of the distribution and (with modification) abundance of Water Voles.

Wildlife Trusts - The Water Vole Watch project was established in 1997 by the Wildlife Trusts in collaboration with the Universities of Oxford and Newcastle. Volunteers were asked to survey stretches of river (selected by the volunteers themselves) for signs of Water Voles. A simple recording form allowed volunteers to note the presence of Water Voles and their signs and to record basic habitat information. No systematic selection of sampling areas was undertaken and in its current format, the survey provides little information of value to the monitoring of temporal or spatial trends in Water Vole populations.

National Water Vole Breeding Programme - Although not specifically a monitoring programme, consideration is being given to the efficacy of reintroduction and translocation as a conservation tool for Water Voles. Monitoring of released populations is being undertaken by Sparsholt College Hampshire, together with an examination of suitable release methods. A planned reintroduction at the Arundel Wetlands and Wildfowl Trust reserve is due to take place later this year (Mike Jordan pers. comm.). This will involve 80 individuals, half of which will be followed using radio-tracking for six months post-release. This will be followed by routine trapping carried out every 6-12 weeks. A further release of 100 individuals is planned for the WWT Barn Elms reserve at a later date.

Other projects - A number of other local projects involving the monitoring or surveying of specific catchments are being carried out across the United Kingdom. These are listed in The Mammal Society's Current Projects and include work examining the establishment of 'key sites' in England and Wales as the basis for long-term monitoring. This work is due to commence late in 1999 (Paul Bright, pers. comm.).

8.2 MONITORING OBJECTIVES

Within the 'Future Research and Monitoring' section of the Water Vole Biodiversity Species Action Plan are two aims that point towards the type of monitoring required for this species (Anon 1995). These are:

5.5.3 to seek to establish a National Water Vole monitoring scheme based on indices and regular survey of key sites in all counties.

5.5.4 to carry out a survey to determine the distribution of Water Voles throughout Britain, identifying key populations in all counties and regions.

This suggests that a two-tier approach should be adopted, with periodic national surveys (ideally within the grid of sample squares already established), supported by annual monitoring at a number of sites across the UK. The lack of quality spatial data resulting from methodological problems with the current national survey suggests that the collation of distributional data should be a high priority. This does not necessarily require a completely new national survey; there is a lot to be gained from building upon the two surveys already carried out. Instead, an examination of potential spatial bias within the VWT data may determine whether a calibration exercise could
be used to improve the spatial quality of the data. High quality data already exist for specific river catchments and efforts should be made to draw these together, identifying those catchments for which additional data is urgently required.

The 94% decline reported for this species (Don Jefferies, pers. comm.) highlights the immediate action that needs to be directed towards its conservation.

8.3 POTENTIAL MONITORING TECHNIQUES

Live-trapping - Capture-Mark-Recapture methods may be used at 'core' sites where the majority of individuals present appear to be readily caught using wire mesh traps baited with mashed carrot and/or chopped apples (Stoddart 1970; Airoldi 1976; Woodroffe et al. 1990). Trapping at 'Peripheral' sites was found to be ineffective by Woodroffe et al. (1990) even when high levels of Water Vole activity were registered. Trapping at both types of site should be carried out between early spring and late autumn, with traps positioned as near to the water as possible. Traps placed on purpose built rafts may be equally or more effective as indicated by Water Vole responses to Coypu traps placed on baited rafts (Baker & Clarke 1988). Stoddart (1970) provides a suitable trap design. Trapping should involve a prebait period followed by three days of trapping with traps set at a 20m spacing (Mike Jordan, pers. comm.). This species can be readily caught during the breeding season, but is very difficult to catch between November and March.

Direct sightings - Direct counts of individuals are likely to be unreliable given the difficulties in approaching this species and because of colony structure.

Field signs - Various field signs may be used to detect the presence of Water Voles at a site, with breeding season latrine counts in particular potentially providing a measure of abundance (Woodroffe et al. 1990; Strachan & Jefferies 1993; Morris et al. 1998, MMR). The value of latrine counts in determining abundance relies on assumptions regarding the ratio of latrines to individual voles. Reanalysis of Woodroffe et al.'s (1990) data by Morris et al. (1998) suggests a roughly 1:1 relationship between the number of latrines and the number of voles and not the 6:1 relationship for the Yorkshire sample as reported in MMR. However, other radio tracking work undertaken by WildCRU suggested some six latrines per vole. Since latrines appear to serve a territorial purpose, the number produced per vole could be expected to vary with population density, season and site. This may reduce the effectiveness of the widespread application of latrine counts as a means of assessing abundance, unless more information can be gathered on the relationship between latrine production and vole density. Provision of dropping boards may improve the ease with which latrines can be found in difficult habitats. It should be noted that there is no latrine formation above ground in the winter and that the persistence of latrines is very dependent upon water level (Mike Jordan, pers. comm.).

Counts of burrows and runways, although they are readily identified, may be biased by the fact that these features may continue to exist after a colony has become extinct (Woodroffe et al. 1990). Only the presence of tracks provide an indication of Water Vole activity away from 'core' sites, although the difficulties in separating Water Vole tracks from those of Brown Rat make this method unsuitable for widespread or amateur use.

Mammals on Nature Reserves - Records of Water Voles on nature reserves could be collated according to the suggestions outlined in Part III.B.6.
Waterways Breeding Bird Survey (WBBS) - Water Vole, along with Mink and Otter, is one of the few species that could be monitored through the WBBS, although it should be stressed that this survey is currently still in its pilot stages and may not have funding for continuation beyond the end of the pilot period. Additionally, the survey is designed to survey a range of bird species associated with riparian habitats and is therefore not ideal for the transect monitoring of Water Vole field signs.

Other alternatives - Questionnaires or Reporting Cards could be used to gather data on an *ad hoc* basis from anglers, Wildlife Trust members, river keepers and boat users. While such an approach may highlight those areas in which Water Voles occur, it will not provide the type of data required for monitoring purposes.

8.4 POTENTIAL MONITORING SCHEMES

The established grid of Water Vole survey sites, within which two national surveys have already been undertaken, provides a monitoring framework that has documented a 94% reduction in Water Vole occurrence (Don Jefferies, pers. comm.). To replace this scheme with an alternative would effectively remove what is an important historical dataset. As has been stressed elsewhere, such replacement should only be the preferred option where a current scheme fails to deliver suitable monitoring information or is prohibitively expensive. Although there is a degree of spatial bias in the Water Vole dataset, due to the manner in which the data is gathered, it does provide quality data on temporal trends in the population (see Recent and Ongoing Monitoring Work - VWT survey 1989/90). The rapid decline witnessed for this species may suggest that more regular monitoring work is undertaken and with a 94% decline already witnessed, there is urgent need for a coherent strategy to be put in place. Priority action may require that resources are targeted towards preserving the remaining populations, removing causal factors and investing in future captive breeding and release schemes. The nature of planned action will itself partly determine the monitoring structure required. It would be prudent to base monitoring decisions on the data published in the second Water Vole Survey Report (due end 1999) rather than to make and act on recommendations now.

Potentially there is a great deal to be gained from undertaking more detailed monitoring within specific catchments, either where measures to safeguard Water Vole populations are being implemented or where populations are to be reintroduced. Such monitoring work would need to be linked to the monitoring of those factors implicated in the decline, specifically Mink populations and habitat degradation. This work could be based on a transect approach, involving the location of field signs (specifically latrine counts) supported by detailed work in a range of habitats to determine the relationship between the number of voles and the number of latrines. An understanding of Water Vole abundance at study sites should be considered a priority over the recording of simple presence/absence data. Data showing a decline in abundance at sites will provide earlier indications of a decline than data merely showing presence or absence at a site. This will be especially important if existing sites are to be protected and their Water Vole populations stabilised. The evaluation of 'key sites' as a basis for monitoring in England and Wales is due to commence later this year. The success of this approach for the Common Dormouse suggests that it may be equally applicable for Water Voles.

While both the VWT national method and that proposed by MMR can provide broad-based monitoring data at the national level, it might be better to target the limited resources more
towards priority catchments, long-term refuges and Water Vole/Mink interfaces. These catchments could be studied in detail, possibly involving local Wildlife Trusts and Environment Agency officers, in an attempt to undertake regular and detailed monitoring, additionally gathering other data on the presence of Mink, river quality and habitat structure. This additional data collation could be based on the Environment Agency's River Habitat Survey (Raven et al. 1997), a method recently adopted and linked to the recording of waterways breeding birds (Buckton & Ormerod 1997; Marchant & Gregory 1999).

Timing of fieldwork should be evaluated through pilot fieldwork or by drawing upon published data on the seasonality of latrine production. Similarly, the number of transects required and their length and placement, should be the subject of fieldwork trials, possibly using the validation work already undertaken by MMR, or expanding on that planned for the monitoring of 'key sites'. Data from the two national surveys could be used to model the best sample sizes, their distribution and periodicity of coverage.

### 8.5 DEVELOPMENT AND VALIDATION STUDIES

A data-modelling exercise (using data from the two national Water Vole surveys, once they are available) should be used to establish whether the number of sample sites can be reduced without reducing the power of the approach for detecting trends of say 25% over 25 years. This exercise could also be used to examine the ideal interval between surveys based on the power of detection and the costs of implementing the survey. This could be carried out at the same time as modelling data for other species (e.g. Badger and Otter). Such analyses are considered in Part VII.

### 8.6 RECOMMENDATIONS

1) No firm decision on monitoring should be taken until the second National Water Vole Survey report is published (end 1999) and the 'key site' approach (5) is evaluated. Once these data become available a study should be initiated to determine a suitable sampling protocol based on simulations, examining sampling interval and the number of sites used. The results of the simulations may demonstrate that a further degree of stratification could be introduced, that sample size could be reduced and that sampling interval could be altered.

2) Allowing for the outcome of simulations in (1), it would be sensible to base future monitoring of this species on the approach adopted for the two VWT surveys (transect search for field signs) and the existing grid of survey sites. However, the survey could be made more cost-effective through the use of trained volunteers to survey individual sites, rather than a single professional observer.

3) In view of the 94% decline due to be reported by the second national survey, work should be carried out using a shorter inter-survey interval than currently used, at least for the short-term. There may also be some value in targeting efforts towards priority catchments (i.e. those with remaining populations or those likely to be colonised by Mink in the coming years).
4) Ancillary data should be gathered through the recording of this species on nature reserves and possibly through the Waterways Breeding Bird Survey.

5) Evaluation of a 'key sites' approach is to be undertaken (Paul Bright, pers. comm.) and findings from this work should contribute to the development of the national monitoring strategy (1). Local monitoring may be an important component of the national strategy, possibly providing information on an annual basis to support the national data collected every five years.

6) Some attempt should be made to examine the level of spatial bias in the two VWT surveys (see Recent and Ongoing Monitoring Work: VWT Survey 1989/90).

8.7 RESOURCE REQUIREMENTS

Co-ordination of monitoring work on this species could be carried out by a single individual (full-time HSO grade - also acting as co-ordinator for Otter and Mink), supported largely by volunteer fieldworkers, with some professional input to the teaching of monitoring methods, validation of data gathered during the survey work and coverage of remote areas.
9. YELLOW-NECKED MOUSE *Apodemus flavicollis*

Native. Believed to be declining in range and abundance, although the rate and magnitude of the decline is unknown. Found predominantly in the south, south-east and west of England and in central and eastern Wales; absent from the southern Midlands.

9.1 RECENT AND ONGOING MONITORING

**National Yellow-necked Mouse Survey** - A 'snapshot' survey was undertaken by The Mammal Society and the University of Bristol during late 1998, using volunteers working with lines of Longworth live-traps (Chitty & Kempson 1949) on sites across England and Wales (Marsh 1999). Trapping was carried out between the start of September and the end of November within deciduous woodland sites greater than two hectares in size and selected by volunteers. Forty traps were operated for two nights to obtain a measure of relative abundance, together with the collation of data on habitat characteristics. The results showed the species to be widespread in suitable woodland within its natural range (occurring at 71% of sites). However, small mammal populations are prone to considerable inter-annual fluctuations (Mallorie & Flowerdew 1994) and this may have influenced some of the results, notably those relating to abundance.

**Mammal Society planned work** - The National Yellow-necked Mouse Survey report outlines future work planned by The Mammal Society on this species. This will look at habitat needs, edge of range densities and precise limits of distribution.

9.2 MONITORING OBJECTIVES

A better understanding of the range limits for this species is required, together with information on long-term population change and persistence of populations in habitat other than mature deciduous woodland. This approach is likely to require annual monitoring to overcome the influence of interannual fluctuations when determining long-term trends and delimiting range. Additionally, more intensive study work should be aimed at examining habitat use outside 'core' habitats.

9.3 POTENTIAL MONITORING METHODS

**Live-trapping** - Longworth live-traps can be used to catch Yellow-necked Mice, using rolled oats as bait and a trap interval of 15m on a grid or transect line. The exact grid arrangement needs to be established and to some extent will be dependent upon the ultimate aims of the monitoring work. A trap-line (or transect) approach will be less suitable for determining abundance than a trapping grid due to the 'edge' effect encountered when trapping (Pelikan 1968; Hansson 1969; Twigg 1975). However, if simple presence/absence is all that is required, then a transect line may be the most appropriate approach because it requires fewer traps.

**Hair tubes** - In practice it may not be possible to separate the hairs of *Apodemus flavicollis* from those of *Apodemus sylvaticus* and the suitability of this method needs further evaluation before consideration is given to its use as a monitoring tool.

**Nestboxes** - Yellow-necked Mice will use nestboxes erected for Dormice or cavity-nesting birds. Where large numbers of boxes are regularly checked (e.g. Pied Flycatcher *Ficedula hypoleuca* or Great Tit *Parus major* schemes) there is the potential for CMR techniques to be applied. The use of such boxes by Yellow-necked Mice is currently being investigated by Aidan Marsh with
preliminary findings suggesting that capture levels in boxes may be too low for CMR techniques to be applied for most sites (pers. comm.).

9.4 POTENTIAL MONITORING SCHEMES

**Live-trapping using woodland grids** - The apparently rather specific habitat requirements of this species make it possible to monitor nationally occurring long term changes in abundance that would be impossible for most other small mammal species. That component of the Yellow-necked Mouse population using mature deciduous woodland is likely to represent the bulk of the population within the UK, although more work should be carried out to confirm this. Assuming that this is the case, so long as enough sites can be covered each year, it should be possible to monitor long-term trends and to remove the effects of differences between individual woodland sites (e.g. seed production, age, species composition). This is still likely to require a significant number of sites, certainly far more than the number covered annually as part of the study by Mallorie & Flowerdew (1994). The minimum number required should be investigated as part of a pilot study, in order to determine whether this approach is economically feasible (see also Part IV.15 - other small mammal species). The pilot work should also examine the number of traps required and the structure of the trapping protocol, although this may be based on either the methods of Marsh (1999) or Mallorie & Flowerdew (1994), although top grids should replace the use of trap lines.

**Ancillary data** - Information on distribution may be obtained from examination of the occurrence of Yellow-necked mice in nestboxes at a network of sites across the UK. This is likely to require increased co-ordination of ongoing schemes to ensure that bird ringers and nest recorders, together with those people working on Common Dormouse boxes, pass information on mice to the appropriate recorders. These people should also be provided with training into how to recognise Yellow-necked Mice and how to separate them from Wood Mice.

9.5 RECOMMENDATIONS

1) A series of woodland study sites should be trapped on an annual basis (to allow for short-term fluctuations with the aim of monitoring long-term changes in abundance as revealed by CMR techniques.

2) Field trials should be carried out to investigate the distribution of Yellow-necked Mice in other habitat types and to determine whether the trapping protocol used for the National Yellow-necked Mouse survey is the most cost-effective for repeated surveys to allow determination of a 25% change in abundance over 25 years.

3) The potential for collation of ancillary data from long-term nestbox schemes should be investigated further.
9.6 RESOURCE REQUIREMENTS

One person could oversee co-ordination of schemes involving the Yellow-necked Mouse, with this individual likely to be involved in the co-ordination of other projects as well. During the pilot phase, additional input is likely to be required as fieldwork trials are carried out. The National Yellow-necked Mouse Survey involved trapping at 168 woods surveyed over a 12 week period. Assuming one set of 40 traps could be used at a single site in any one week, some 14 sets of traps (560 traps - £16,800) would be required, involving c.1,700 hours fieldwork.
10. HARVEST MOUSE  *Micromys minutus*

Native. The species shows a restricted distribution with the majority of records coming from England. Populations are thought to fluctuate between years and there is some evidence of a recent contraction in range.

10.1 RECENT AND ONGOING MONITORING

**National Harvest Mouse Survey (1973-1977)** - A national survey instigated by The Mammal Society in 1973 aimed to establish both the status and distribution of the species within Great Britain. Targeted media appeals were followed up by the collation of record sheets, noting the occurrence of Harvest Mice at various sites. Some 1,205 record sheets were returned by observers allowing a distribution map to be plotted. Records of Harvest Mouse nests accounted for 66.9% of reports, with 8% referring to trapped individuals and 7.6% to remains from Barn Owl pellets (Harris 1979). It was noted that ‘. . . on the fringes of its range, populations of Harvest Mouse were extremely localised, and often difficult to find.’.

**Look Out For Mammals Survey (1996-1997)** - As part of The Mammal Society’s *Look Out for Mammals* project some 800 sites from the 1970s survey were resurveyed to determine whether Harvest Mice still occurred at the sites and to assess the degree of habitat change. The results from this work are currently being analysed, although early indications are that only 29% of historical sites still show signs of activity.

10.2 MONITORING OBJECTIVES

The monitoring of population trends, together with the establishment of range limits should be considered a priority for this species.

10.3 POTENTIAL MONITORING TECHNIQUES

**Live-trapping** - Live-trapping can be carried out using a grid of Longworth live-traps (Chitty & Kempson 1949). Although Harvest Mice can be caught on the ground between September and February, (when the vegetation dies or is cut back), they are more readily caught in the summer months by setting traps some 0.5 to 1m above the ground using bamboo canes (Perrow, pers. comm.). MMR note that seed-baited traps should be set in undisturbed grassland or along field margins using a 7x7 grid with a 15m trap interval, in keeping with home range sizes of 300-400m² (Trout 1978).

**Hair tubes** - Hair tubes (28mm diameter, placed 0.5-1.0m above the ground) have been used by Martin Perrow at the University of East Anglia for much of his work on Harvest Mouse populations. Attempts to calibrate hair tube data against live-trapping data suggest that the use of hair tubes is well suited to this species.

**Field signs (nests)** - The aerial breeding nests made by Harvest Mice are distinctive, typically placed in monocotyledons and are made from finely split and woven grasses. During the period when young are in the nest there is no obvious entrance, although the nest becomes more battered once the female has abandoned the young. The nests are usually spatially separated, so a cluster of two or three is likely to represent successive litters from one female (Trout 1978).
**Artificial baiting nests (Warner & Batt 1976)** - Artificial baiting nests have been developed from tennis balls with the aim of attracting Harvest Mice. A hole is made in the wall of the tennis ball using a 15mm cork borer, before being waterproofed and mounted on a post at a height of 30 to 50cm. Once in position and baited with bird seed, the tennis ball can then be left for five days before being checked to determine if Harvest Mice have taken the bait. This period is thought to be long enough to reveal the presence of Harvest Mice at low population densities (Warner & Batt 1976). MMR note that this approach only provides presence/absence data and that recent countrywide trials by The Mammal Society have been largely unsuccessful.

**Owl pellets** - Harvest Mice occur in Barn Owl pellets (Buckley 1977) although the species is considered to be only a minor prey species (typically up to 3% of dietary intake by number). Analysis of Barn Owl pellets as part of a general pellet scheme could provide useful information on distribution of this species.

**10.4 POTENTIAL MONITORING SCHEMES**

There are two alternative approaches that could potentially be adopted (a) hair tubes - favoured by workers at the University of East Anglia and (b) nest searches - favoured by The Mammal Society. Both are discussed below.

**a) Hair tubes** - Hair tubes should be supplied to a volunteer network of people interested in helping with ongoing monitoring of this species during the summer months. Guidelines should be supplied on where and how to place tubes and tape from tubes should be sent back for analysis at the end of each annual sampling period. Survey work should take place each summer, the data being analysed during the winter and a report sent to all contributors prior to the commencement of the follow year's fieldwork. Each observer should get a mail-merged letter accompanying the material for the following season (new forms, tape, etc.) and the report from the previous season. This letter should contain information on the individual species recorded or presence/absence of *Micromys* by that observer.

It is difficult to predict how many volunteers would be willing to become involved in this project, but the likely number of sites requiring coverage could be determined through an analysis of data from the two Mammal Society Harvest Mouse surveys. Data from the most recent survey are currently being analysed and a sampling protocol should not be finalised until after these data are published. Participants in the most recent survey, together with nature reserve wardens, FWAG field officers, LOFM participants, etc. may be the logical groups to approach in the hope that such people could provide continuous monitoring at sites over time.

Analysis would be undertaken by a single person, not necessarily the person running the scheme, but possibly involved in other monitoring projects of a related nature. Initial inputs to the scheme would require development of guidelines and survey packs, targeted media appeals and general promotion of the scheme. Once established, the preparation of an annual report and analysis of the results should be considered a priority in order to maintain volunteer enthusiasm and recruit new fieldworkers. The proportion of tubes containing *Micromys* hairs could form the basis of an index and provide information on both distribution and abundance.

**b) Nest searches** - Searches for nests could also be undertaken at the sites being covered with hair tubes or as part of an unrelated scheme. Searches are likely to be quick, simple and effective.
with counts of breeding nests providing a quick and simple approach that can be included in transects for field signs in the autumn. This approach could allow more sites to be covered annually than would be possible with hair tubes. Detailed methods for finding sites should be based on The Mammal Society’s *Look Out For Mammals* guidelines.

Ancillary data could come through the recording of presence/absence of Harvest Mice at those nature reserves involved in any monitoring scheme aimed at recording mammals on nature reserves (see Part III.B.6.).

10.5 DEVELOPMENT AND VALIDATION OF STUDIES

A series of live-trapping grids should be placed on a subset of the sites, allowing calibration of the data received from the hair tubes and nest searches. This should only continue for as long as necessary to allow determination of the effectiveness of the two approaches. Pilot work should be carried out to establish the number of sites that need to be covered, together with the number of tubes that should be used per site. It is recommended that either The Mammal Society or the University of East Anglia are approached regarding the pilot work.

10.6 RECOMMENDATIONS

Two alternative schemes (1) and (2) require further consideration and could be supported by ancillary data from other schemes.

1) Annual monitoring of this species could be based on the use of hair-tubes at a number of sites across the known range. Placement of tubes and data collection should be undertaken by volunteers, with tape from the tubes sent to a central co-ordinator for analysis. Results should be reported on an annual basis through a scheme newsletter sent out with the fieldwork material for the following season. The number of sites to be covered and the number of tubes to be used should be determined following discussion with The Mammal Society and researchers at the University of East Anglia.

2) Searches for nests could be undertaken at those sites detailed in (1) or as part of an unrelated scheme. Monitoring of those sites notified during the national Harvest Mouse surveys should continue, using nest searches as the primary fieldwork method. Data from The Mammal Society’s evaluation of artificial baiting nests should be examined in detail to determine whether this method can be applied successfully and whether there are any implications for other monitoring methods.

3) Ancillary data could be gathered through the monitoring of this species on nature reserves (see Part III.B.6).
11. HOUSE MOUSE  *Mus domesticus*

An ancient introduction. Widespread. Strongly commensal: most (but not all) populations outside buildings are probably sinks, dependent on continuing input from populations in buildings. Probably suffered big declines following loss of cereal ricks.

11.1 RECENT AND ONGOING MONITORING WORK

**Housing Condition Surveys (DETR)** - These have been conducted at five-yearly intervals in England and Wales although (the 1996 survey omitted Wales). They have covered a random sample of dwellings in the areas of participating local authorities (participation was complete in 1996 but voluntary before that). The 1996 survey (not yet published) gathered information on the percentage of dwellings infested by mice but we understand that earlier ones did not.

**National Rodent Survey (MAFF)** - Conducted annually during 1976-1979 and 1993, covering business premises as well as houses; the 1993 survey included agricultural premises but the 1976-9 surveys did not (Meyer *et al.* 1995). Covered England and Wales but not all local authorities participated. Recorded infestation rates. For many years prior to 1976, a less formal survey was used to monitor infestation rates roughly (Rennison & Drummond 1981).

**Northern Ireland** - Similar surveys to the Housing Condition Survey have been run.

**Scotland** - Similar surveys to the Housing Condition Survey have been run, but without gathering information on rodents.

**Note on data quality in the above surveys**
Questionnaires commonly refer simply to “mice”; it is furthermore, likely that many respondents would not distinguish between mouse species. Given that Wood Mice are common in houses, at least in rural and semi-rural locations, the above surveys are probably of limited value for monitoring House Mice.

11.2 MONITORING OBJECTIVES

House Mice are not good wildlife indicators because they are so commensal with humans and their numbers depend so much of the efficacy of measures taken to control them. They are probably of little significance in most natural and semi-natural ecosystems in the UK. Conservation of the species in its own right requires that we need to be aware of catastrophic declines in its numbers.

11.3 POTENTIAL MONITORING TECHNIQUES

**Questionnaire surveys of local authorities** - These are limited use because of the problem of species identification (see above).

**Questionnaire surveys of pest-control companies** - Company representatives have suggested to us that these would be of limited value because of the problem of species identification and because companies do not routinely collate data in a form that could be useful for monitoring.
Pest-control data from specific sites - At many commercial sites, mice and rats are routinely controlled in continuous programmes of work. Typically, contractors visit sites 2-8 times per year to determine whether pest species are present (and to take action to control them if they are). The proportion of visits yielding positive records could provide an index of House Mouse and Brown Rat at each site.

Trapping - House Mice are relatively easy to trap, so trapping rates at a site could provide an index of numbers at that site.

Direct sightings - House Mice are too rarely observed (even in gardens) for most schemes based on direct observations to provide much useful data.

Owl pellets - House Mice are scarce in owl pellets.

11.4 POTENTIAL MONITORING SCHEMES

Questionnaire survey of local authorities - Despite the identification problems, this may be the only feasible way of getting some sort of measure of changes in the national House Mouse population. Local authorities might only co-operate if it was part of a broader survey of housing conditions.

Gathering pest control data from specific sites - There are several hundred pest control companies, each managing pests at many sites. Some may be prepared to provide data as a way to promote the industry’s positive image. Client confidentiality could be a problem but there is not need to exact locations to be revealed. The British Pest Control Association could provide a link with some of the companies. Guidance on identification would be needed.

Trapping - Given the patchiness and great temporal variation of House Mouse populations, a scheme based on trapping animals would probably only deliver a useful national index if it involved some hundreds of sites. This would be very expensive.

Owl Pellets Scheme - House Mice would automatically be included in a scheme but the numbers of House Mice in the samples would probably be too low to be useful.

Garden Mammal Watch - House Mice should probably be included, to allow observers to record them, but the number of observations is likely to be too few to be useful (and there may be identification problems).

11.5 RECOMMENDATIONS

1) House Mice should be included in the Owl Pellets Scheme.

2) House Mice should be included in Garden Mammal Watch.

3) The value and best way of including rats and mice in future surveys like the Housing Condition Survey should be assessed after the report of the 1996 Survey is published.

4) If monitoring through the Housing Condition Survey is judged unfeasible, consideration should be given to gathering site-specific data from pest-control companies.
12. **BROWN RAT** *Rattus norvegicus*

Eighteenth century introduction. Widespread. Largely commensal but less so than House Mouse; as well as in buildings, it is common in refuse tips, in sewers and along urban waterways. Populations on arable land may move more into agricultural buildings after harvest. Natural habitats are occupied along the coast. Numbers have probably declined greatly this century, consequent on more efficient harvesting and storage of food and on highly effective poisons.

**12.1 RECENT AND ONGOING MONITORING WORK**

See House Mouse: all of the surveys listed under that species also covered Brown Rats, as did the 1991 Housing Condition Survey.

**Note on data quality in these surveys**

Although questionnaires commonly refer simply to “rats” and it is likely some respondents would not distinguish Brown from Ship Rats, the latter are so scarce that the information provided by the surveys is genuinely relevant to Brown Rats.

**12.2 MONITORING OBJECTIVES**

Brown Rats are poor wildlife indicators for the same reasons as House Mice. Populations in natural and semi-natural ecosystems may be important predators (especially of seabirds on islands) and they are sometimes significant in the diet of larger predators. Thus we need to be aware of substantial changes in numbers of Brown Rats.

**12.3 POTENTIAL MONITORING TECHNIQUES**

**Questionnaire surveys of local authorities** - Provide an index of how abundant and widespread Brown Rats are.

**Questionnaire surveys of pest-control companies** - Of limited use because companies do not routinely collate data in a form that could be useful for monitoring.

**Pest-control data from specific sites** - At many commercial sites, mice and rats are routinely controlled in continuous programmes of work. Data from such sites could provide an index of population levels at each one.

**Game Bag data** - The recording of rats in Game Bags is almost certainly too sporadic to be useful.

**Trapping** - Rat traps are more cumbersome than mouse traps and Brown Rats often difficult to trap, but trapping could be used to index their numbers at individual sites.

**Direct sightings** - Brown Rats are not infrequently observed in gardens and in the countryside, though they are generally shy and nocturnal.

**Owl pellets** - Rats occur not uncommonly in owl pellets.
12.4 POTENTIAL MONITORING SCHEMES

Questionnaire survey of local authorities - See House Mouse.

Gathering pest-control data from specific sites - See House Mouse.

Trapping - See House Mouse; because of the larger traps and the neophobia exhibited by rats (leading to smaller numbers of catches per trap-night), the costs would be even greater for rats.

Owl Pellet Scheme - Brown Rats would automatically be included in such a scheme; they may be recorded often enough for this to provide a useful index. Though most rats found in owl pellets are young ones, so their frequency is not a good indication of adult numbers.

Garden Mammal Watch - Brown Rats should be included; they may be recorded often enough for this to provide a useful index.

Mammals on Nature Reserves - Brown Rats should be included; they may be recorded often enough for this to provide a useful index.

12.5 RECOMMENDATIONS

1) Brown Rats should be included in the Owl Pellets Scheme.

2) Brown Rats should be included in Garden Mammal Watch.

3) Brown Rats should be included in the Mammals on Nature Reserves Scheme.

4) The value and best way of including rats and mice in future surveys like the Housing Conditions Survey should be assessed after the report of the 1996 survey is published.

5) If monitoring through the Housing Condition Survey is judged unfeasible, consideration should be given to gathering site-specific data from pest-control companies.
13. **SHIP RAT *Rattus rattus***

Introduced. Established populations in Britain and Ireland reduced to a few on islands (Lundy, Shiants, Forth Islands) and one on the mainland (Tilbury); sporadic occurrences in ports (from ships) and supermarkets (from lorries).

(Note that there seems to be no published reference to the occurrence of Ship Rats on the Forth islands but Mr William Penrice of Fife Nature has told us that a specimen from Inchcolm was supplied by a rodent controller in 1998; there is a local belief that the species has been present on the island for some years, perhaps alongside Brown Rats as on Lundy; there are also suspicions that Ship Rats may be established on Inchmickery and Inchkeith)

13.1 **RECENT AND ONGOING MONITORING WORK**

We understand the Port of London Authority have good records for its area.

Both the Lundy and Shiants populations are the subject of sporadic investigation by university and similar groups (Smith *et al.* 1993; Key *et al.* 1998).

Dr Graham Twigg has surveyed Ship Rat distribution by questionnaire (Twigg 1992) and continues to collate reports of the species.

Fife Nature intend more fully assessing the species’ status on the Forth islands.

13.2 **MONITORING OBJECTIVES**

We suggest that the national priority for this introduced species of limited distribution should be to monitor its range. Should it be considered appropriate either to eliminate the island populations or to take steps to maintain them, then appropriate local monitoring should be undertaken.

13.3 **POTENTIAL MONITORING TECHNIQUES**

**Live-trapping** - Trapping (with or without mark and recapture studies) is an effective way of monitoring Ship Rats.

**Field signs (fur smears and droppings)** - Field signs can be distinguished from those of Brown Rats with experience.

Questionnaire surveys of pest control companies, local authorities, environmental and public health authorities and port authorities can provide some evidence of occurrence and infestation rates but there may be problems of distinguishing the two species of rat. Twigg (1992) was able to get useful information on the changing fortunes of Ship Rats in the UK from such a survey, though he attempted to gather records going back over three decades, with the result that the data for earlier years were sparser because of the passage of time.)
13.4 POTENTIAL MONITORING SCHEMES

A. Island populations

Since these are isolated and of little relevance to the country as a whole, these populations can be treated as independent units.

MMR recommend standardised live-trapping for these populations but the monitoring that should be undertaken depends on the view that is taken of the way in which they should be managed and, thus, on the strategic conservation objectives for these populations. Broadly speaking, the possibilities are:

1. Letting nature take its course

In this case, monitoring is unnecessary. We would recommend, however, that the statutory agencies collate information on these populations as it becomes available.

Resource requirement: a few hours per year on top of the time input of those providing the information.

2. Eliminating the populations

This is feasible. Success could be determined on the Shiant Isles by using the standard technique of bait sticks; on Lundy, where Brown Rats are also present, this would need to be supplemented by sign surveys or trapping if one wished to know whether Ship Rats had been eliminated even though Brown Rats had not. Similar methods could be used on the Forth islands.

Resource requirement: difficult to estimate; the monitoring of success would be an integral part of the control programmes.

3. Maintaining the populations

On Lundy, the population could be readily indexed by using a systematic programme of live-trapping, since there is a reserve warden on the island in whose duties such work could be incorporated. It would probably be useful to trap in late winter (when natural food is scarce, so that trapping rates will be enhanced, but numbers are likely to be low) and in late autumn (when numbers will be high but variable, depending on breeding success).

On the Shiant Isles, which are difficult of access, standardised live-trapping (i.e. at the same time of year and in exactly the same sites) could provide useful data. A less-standardised programme of trapping would be much less cost-effective. Given the cost of getting people onto these islands, it may be preferable to undertake a major trapping programme every few years rather than to undertake a smaller programme annually, despite the likelihood of considerable annual fluctuations in numbers.

Rats are routinely trapped on at least some of the Forth islands. It would be possible, in principle, to collate data on numbers trapped and trapping effort; if Brown Rats prove also to be present, there might be identification problems.
B. Mainland populations

It may be possible to get useful information on Ship Rats at the same time as monitoring Brown Rats and House Mice. If such monitoring is not undertaken, or if gathering information on Ship Rats is considered too specialised to be included in the monitoring of these common species, then we suggest that a quinquennial questionnaire survey should be conducted of: the area offices of major pest control companies, local authorities, environmental and public health authorities, and port authorities. MMR recommend annual questionnaire surveys but, given that the majority of Ship Rat reports apply to occasional individuals or to ephemeral populations we believe that this is unnecessary. Such frequent surveys, for which the majority of responses were negative could alienate potential respondents.

13.5 RECOMMENDATIONS

1) Monitoring of island populations should depend on a clear decision being reached as to the strategy conservation objectives for these populations (see above).

2) Mainland populations should be monitored through quinquennial questionnaire surveys.
14. COMMON DORMOUSE  *Muscardinus avellanarius*

The Common Dormouse population has undergone a pronounced reduction in range and abundance this century. Populations are threatened by loss and fragmentation of suitable habitats, and by the inability to respond quickly to environmental change.

14.1 RECENT AND ONGOING MONITORING WORK

**Mammal Society Dormouse Survey (1975-1979)** - The Dormouse survey was initiated by The Mammal Society in January 1975 and ran until April 1979 (Hurrell & McIntosh 1984). Details of the survey were circulated with record forms to all known natural history societies, county naturalists' trusts and museums in England, Wales and Scotland. Some of the areas from which relatively few responses were received were examined in greater detail through field visits. Four-hundred and seventy-four completed record sheets were received, allowing distribution to be determined. No information was available on the abundance of the species within its established range.

**Mammal Society Dormouse Survey (1993-1994)** - Termed the 'Great Nut Hunt' a national distribution survey was undertaken as part of an exercise to raise the public awareness of Dormouse conservation issues. Approximately 11,000 survey packs were distributed to schools, naturalists and the general public resulting in the return of 1,878 report forms. A total of 13,171 nuts were sent in for confirmation that they had been opened by Dormice, as recorded by the observers (Bright *et al.* 1996a). However, only 1,352 (10.3%) of these had been opened by Dormice, the majority (63%) having been opened by squirrels. This was possibly the result of the survey packs having been distributed to too wide an audience. Three-hundred and thirty-four individual Dormice sites were identified from the submission of nuts opened by Dormice. Some attempt was made to quantify the relative abundance of the species across the country on the basis of the submissions received, but the resulting measures may be unreliable because there was no indication of how search effort varied between observers.

General agreement between the two Mammal Society surveys, along with that from work in Wales (Bright 1995), appears to confirm the contraction in range of this species, although it fails to provide data allowing changes in abundance to be properly assessed.

**National Dormouse Monitoring Scheme** - This scheme collates data from 'Key Sites' within the known range of the species. It aims to gather long-term data on an annual basis, providing information on annual variation in breeding success and population density across habitats and regions. Those participating in the scheme do so on a voluntary basis and receive feedback in the form of an annual newsletter. Typically, three or four observers cover each of the 70 or so monitoring sites, with the observers coming from a general mammal background.

14.2 MONITORING OBJECTIVES

The Common Dormouse was included in the review of scheduled species (Whitten 1990) and the UK Biodiversity Steering Group Report (Anon 1995), and is the subject of a Species Action Plan prepared by English Nature. Action Plan objectives laid down by Bright *et al.* (1996b) contain recommendations for future monitoring of this species, namely:
(a) 'Collation of data from the National Dormouse Monitoring Scheme, its analysis and dissemination. The purpose is to study long-term effects of habitat change on population density and breeding success, and also climatic effects on yearly and geographical variation in population size and viability. More sites and observers should be recruited into the monitoring scheme. The target should be to maintain surveillance of Key Sites in at least 25 counties, recruiting at least three new sites per year until the year 2000 and beyond.'

(b) 'Periodically (every 5-10 years), a survey should be undertaken of sites where dormice have been recorded in the past (using The Mammal Society Survey site list and the Great Nut Hunt of 1993 as the baseline data). [The next 'Great Nut Hunt' is planned for 2001]. The purpose will be to establish the rate at which sites are being lost and to ensure that widespread extinctions do not occur unnoticed.'

Bright & Morris (1996) note that the Dormouse is likely to be '.. a very sensitive indicator species for monitoring future changing environments and an excellent model for studying the effects of habitat fragmentation, climatic shifts and climatic stochasticity'. To achieve these aims, and those mentioned above, annual monitoring of Key Sites should be a priority, coupled with an examination of Dormouse abundance within hedgerow habitats and periodic national surveys of distribution.

14.3 POTENTIAL MONITORING TECHNIQUES

Live-trapping - Dormice can be trapped in purpose-built wire-mesh traps (Morris & Whitbread 1986). These should be baited with apple, contain a nestbox (typically a clean milk carton) filled with hay and be positioned between 1 and 4m above the ground, set against trunks or in suitable cover. MMR recommended that a grid of 7x7 traps is positioned with a 15m trap spacing. Traps should be run over a five-day trapping period and checked twice daily. Capture rates are low and the method is very labour intensive.

Hair-tubes - Hair-tubes can be used to record the presence of Dormice in an area and provide a simple measure of activity. Tubes should be 3-4cm in diameter, contain sticky tape on the upper surface, be baited with jam or peanut butter and fixed at 1-3.5m height to the trees. The best arrangement of tape within the tube is subject to some debate. Bright et al. (1996b) recommend tape be placed across two openings cut across the roof of the tube, while Jordan (pers. comm.) recommends (for general hair-tube use across species) that tape be placed length-ways along the tube roof. Correct identification of Dormouse hairs requires expert knowledge or formal training and access to a microscope.

Field signs - The way in which hazelnuts are opened by the Common Dormouse is characteristic and apparently relatively straightforward to identify, although it should be noted that many of the respondents to the 'Great Nut Hunt' failed to separate correctly squirrel- and dormouse-opened nuts (Bright & Morris 1989; Bright et al. 1996b). Five 10x10m quadrats placed within suitable habitat should be searched for 20 minutes each (Bright et al. 1994). If no positive nuts are found then it is likely that the species is absent from the site. Searches should be undertaken from about mid-September to the end of December. This approach cannot be applied to Dormouse populations utilising hedgerow habitats. However, work is planned to examine the relationship between Dormouse abundance and hedgerow characteristics at 60 sites in England and Wales (Paul Bright, pers. comm.).
Summer Dormouse nests are characteristic when freshly constructed, having tightly woven material (typically strips of Honeysuckle) bound together with leaves (Hurrell & McIntosh 1984). Nests are usually spherical, lacking any obvious entrance hole and are grapefruit-sized (Bright et al. 1996b). The lack of an obvious entrance hole distinguishes them from the nests of Wren Troglodytes troglodytes and Harvest Mouse.

Nestboxes - From the work of Paul Bright it is clear that nestboxes can provide an important tool for monitoring Dormouse numbers and breeding success (Morris et al. 1990). A description of suitable nestbox designs is provided by Bright et al. (1996b). Inspection of nestboxes under licence should be carried out at least twice a year (mid-June and mid-October), although more regular checks will provide greater detail.

Nestboxes erected for other species, notably Pied Flycatchers Ficedula hypoleuca, may occasionally contain Dormice. The number of boxes occupied each year could provide a basic index of the species at sites where nestbox schemes are regularly monitored. This is currently being evaluated by Aidan Marsh primarily with regard to Yellow-necked Mouse use of bird boxes (Aidan Marsh, pers. comm.).

14.4 POTENTIAL MONITORING SCHEMES

National Dormouse Monitoring Scheme - The present National Dormouse Monitoring Scheme, with its emphasis on 'Key Sites' and periodic national surveys, already provides data of the type required for the successful monitoring of this species. The monitoring network has grown steadily since the mid-1980s and with continuing efforts to expand the number of sites covered annually (and the range of habitats), no alternative monitoring scheme would appear necessary. Work should continue to evaluate the success of the translocation programme (Bright & Morris 1993, 1994) and other aspects of Dormouse conservation (Bright et al. 1994): e.g. Morris (1993) stresses the need to establish what constitutes a minimum viable population for this species. Additional funding may be required to extend the range of habitats and regions covered further.

14.5 RECOMMENDATIONS

1) The current National Dormouse Monitoring Scheme already provides suitable data for monitoring this species. The scheme could be expanded through additional funding to cover sites in a number of other habitats and regions.

2) Ancillary data would be available on distribution from the proposed Mammals on Nature Reserves scheme (Part III.B.6).
15. FAT DORMOUSE  *Glis glis*

Introduced into Tring Park, Hertfordshire in 1902. The population has steadily expanded its range since that time and now occupies a triangle of 260km$^2$ delimited by Beaconsfield, Aylesbury and Luton where it is locally numerous (Thompson & Platt 1964; Hoodless & Morris 1993; Morris 1997).

15.1 RECENT AND ONGOING MONITORING

In addition to the collation of sightings on an *ad hoc* basis:

**DETR** - Licences are required under the Wildlife and Countryside Act for the purposes of trapping *Glis*. Pest Control companies operating under such licences are required by law to submit details of where (and how many) animals are caught when carrying out pest control operations. This data could be made available for monitoring purposes, although some of the detail may be withheld (Kevin Rye (DETR), pers. comm.).

**Study by Pat Morris and Paul Bright** - Ongoing work is being carried out in a wood within the core range of *Glis* examining basic ecology and survival rates. One-hundred and thirty nestboxes, with additional nesting tubes (converted tree guards), have been positioned along lines in 20 hectares of woodland to allow sampling of different woodland compartments. Monthly visits are made between May and November and individuals caught are marked with implanted chips, allowing the application of CMR. To date over 170 individuals have been marked with tags, with others previously having been marked with ear tattoos. This information is being used to determine survival rates and additional information is available on productivity and recruitment.

15.2 MONITORING OBJECTIVES

Any expansion in range would be a cause for concern, especially given the potential damage that this species can cause to forestry and domestic properties. Although the population has yet to spread much further afield, this may simply be the result of it not yet having saturated the already colonised area (Lever 1994) and of difficulties in moving across areas of unsuitable habitat. Assessment of current distribution and some basic information on densities within the occupied range should be considered a priority. It is established that some individuals removed from properties have been released at some distance and this may have contributed to the expansion in range of this species.

15.3 POTENTIAL MONITORING TECHNIQUES

**Line-transects** - In early summer Fat Dormice are particularly vocal, emitting raucous chirring vocalisations soon after emergence at dusk. Transects can be walked at this time and the number of *Glis* heard can recorded (Pat Morris, pers. comm.) using a distance sampling approach. This approach was used by Hoodless & Morris (1993) to estimate population density, with 550m transects each walked a total of nine times between the hours of 2130 and 0100hrs over four separate nights. Transects should be walked on still nights to reduce the interference caused by background noise.
**Live-trapping** - The species is noted by Lever (1994) to be readily trapped. Commercially available squirrel traps can be used, under licence, to capture this species (Pat Morris pers. comm.).

**Nestboxes** - The work carried out by Pat Morris highlights the potential for monitoring through the use of nest boxes. *Glis* readily take to nestboxes and nesting tubes and can be caught outside the hibernation period in such sites. Both nestboxes and nesting tubes appear to be equally suitable for this species (Morris & Temple 1998).

**Infestation records** - Licences are required for the purposes of trapping *Glis*. Pest control companies operating under such licences are required by law to submit details of where (and how many) animals are caught when carrying out pest control operations. This data could be made available for monitoring purposes, although some of the detail may be withheld (Kevin Rye (DETR), pers. comm.).

### 15.4 MONITORING OPTIONS

**Annual Monitoring** - The restricted distribution of *Glis*, coupled with its habitat requirements suggests that successful monitoring of this species may be possible through annual monitoring of nestboxes at a small number of sites (possibly even one). *Glis* require high beech forest mixed with conifers, a combination that is untypical of much British forestry, but which does occur in the Chilterns. Monitoring of a grid of nestboxes and nest tubes within such habitat on an annual basis outside the hibernation period could be used, through the application of CMR, to derive an index of abundance. The manner in which data are currently gathered by Pat Morris (monthly visits May-Nov) additionally provides information on productivity, recruitment and survival rates, all of which are important if we are to understand the ecology (and possible control measures) of this species within Great Britain. The current scheme is unfunded and funds would need to be made available to secure the continuation of the work and its possible expansion to a limited number of other sites within the known range. The apparent synchronicity between the GB population and those elsewhere in Europe further supports the possibility of monitoring using just a small number of sites or a single site. It would make sense to have several study sites, thus reducing the risk of loss of monitoring following a change in access conditions.

**Pest Control returns** - The data generated by the above annual monitoring does not provide information on that component of the population utilising buildings for part of the year. Information gathered by pest control companies and reported to DETR through licence returns could be used to generate an index of *Glis* occurrence in buildings. This should be examined in relation to data from the wider countryside, although it is not clear at this stage whether the two components are likely to show positive correlations or negative ones (Pat Morris, pers. comm.). There are good biological reasons why either may occur.

**Transects** - Periodic transect surveys for *Glis* vocal activity can be carried out to examine the distribution, and to a lesser extent the abundance, of the species at a larger number of sites. The protocol for this approach needs to be evaluated through pilot fieldwork examining the best time for carrying out such work and the length of transect required (see Hoodless & Morris 1993).
15.5 RECOMMENDATIONS

The current monitoring work being carried out by Pat Morris should be formalised through the provision of specific funding, allowing extension of the scheme into a small number of other sites. This would provide sufficient detail to monitor population changes of 25% over 25 years through CMR techniques. Additionally it would provide important information on productivity and basic ecology, both of importance if the potential future control of the *Glis* population is to be effective.
16. OTHER SMALL MAMMAL SPECIES
(Common Shrew Sorex araneus, Pygmy Shrew Sorex minutus, Water Shrew Neomys fodiens, Bank Vole Clethrionomys glareolus, Field Vole Microtus agrestis and Wood Mouse Apodemus sylvaticus.)

The remaining small mammal species have a wider distribution and broader habitat requirements than species such as Yellow-necked Mouse and Harvest Mouse. Consequently they present particular difficulties with regard to monitoring. For this reason they have been grouped together and the structure of this section has been adapted accordingly to allow examination of the problems associated with monitoring these species and any potential monitoring strategy. For the purposes of explaining some of the difficulties in working with this group the Wood Mouse is used as an example. Specific problems associated with the other species are readily available within the wide-ranging literature on small mammals.

16.1 MONITORING OBJECTIVES

Small mammals are an important component of our mammal community. Some species are of economic importance (Wood Mouse), others of limited distribution or conservation interest (Water Shrew, Harvest Mouse) and all are important as prey species for some of our scarcer carnivores and predatory bird species. There is evidence of a widespread decline for species like Field Vole, Water Shrew and Harvest Mouse, with Action plans having been drawn up for some species (Churchfield 1997). Monitoring should be directed towards establishing long-term trends in abundance across a range of habitats.

16.2 DIFFICULTIES WITH THIS GROUP

Scale - The main difficulty in developing a suitable monitoring strategy for this group is one of scale. Most of these species will use a range of habitat types and all are widely distributed within Great Britain, although within habitats they often exhibit very clear microhabitat preferences. In the case of the Field Vole, the species can be found in unimproved grasslands, roadside verges, young conifer plantations and (at lower population densities) in woodland. In these habitats it shows a preference for areas with a lush growth of soft grasses, a high basal density to the sward and well-developed tussock structure (Ferns 1976, 1979).

The Wood Mouse is more of a habitat generalist, occurring in most habitats: woodland (Flowerdew 1985; Montgomery 1989), arable land (Rogers & Gorman 1995), sand dunes (Deshmukh & Cotton 1970), hedgerows and urban areas. The widespread occurrence of this species, coupled with its abundance, makes monitoring on the basis of simple presence/absence quite impractical. The only alternative is to look at abundance. However, this also presents problems in that there are various biases associated with the application of Capture-Mark-Recapture (CMR) methods and difficulties in selecting a sample of sites that represents the wider habitat use of the various species.

Trapping at a small number of sites (say 30 woodland sites) is unlikely to provide a realistic picture of what is happening to the Wood Mouse population at the national level. The abundance of the species at each site will depend on both the habitat type and the microhabitat features present on the trapping grid. This will lead to a high degree of variation between sites, as sites differ in age, food availability, the proximity of source/sink populations, etc. The only way to overcome the effects of this between-site variation (site-effect) is to sample at a large number of sites, across all utilised habitats. This may greatly increase the number of samples that need to be
taken in order to obtain a suitably precise measure of the underlying trend (year effect). Mallorie & Flowerdew (1994) examined data from a series of 13 study sites in deciduous woodland employing standardised trapping in an attempt to determine whether there was synchrony between populations. Analysis of variance of the effects of trapping sites and year on log, numbers of Wood Mice and Bank Voles showed both significant year and site effects, suggesting that it is possible to get at year effects, at least in similar woodland habitats, with this number of samples. However, the synchrony found by Mallorie & Flowerdew (1994) appears to be related to masting events (Flowerdew 1973) and similar synchrony is less-likely to occur in non-woodland habitats. It should be noted that synchrony has also been demonstrated in other woodland/forest habitats (Shanker & Sukmar 1999) This is further complicated by the influence of source/sink dynamics.

**Number of samples required** - To build up an accurate picture of what is happening to Wood Mouse populations at the national level it is important to sample a representative suite of habitats within which the species is known to occur. For a large species of mammal or bird the size of the sample unit (e.g. tetrad, 1km square) is typically large enough to ensure that a representative sample of available habitats can be covered within a reasonable number of units, enabling a national estimate to be produced - i.e. the sample is representative of the wider countryside (Toms et al. 1998). With small mammals, the sample unit is much smaller, typically a grid of less than a hectare in size. A larger number of these units would then need to be covered if they are to be representative of the wider countryside. In the case of a small mammal showing a restricted distribution (e.g. Dormouse, Harvest Mouse) this may be possible in that the species has specific habitat requirements, but for a habitat generalist like the Wood Mouse this is more difficult to achieve. The number of samples required may be prohibitively expensive in terms of the man hours required and the capital costs involved (see worked examples).

**Biases relating to the trapping of small mammals** - The biases associated with trapping small mammals and the CMR method have been well covered by MMR. Typically, such biases result from the number of traps used per trap point (Andrzejewski et al. 1966; Gurnell 1976), trap position, length of the trapping period (Andrzejewski & Glogowska 1962), weather (Vickery & Bider 1981), trap odour (Tew 1987) and density of the population under study (Janion & Wierzbowska 1970). In addition to those biases applicable across habitats, there will be other biases specific to individual habitats. Biases associated with small mammal trapping and the use of traps are reviewed by Flowerdew (1976) and Twigg (1975) respectively. The timing of sampling is another important factor due to (i) regular annual cycles witnessed in most small mammal populations (Stenseth et al. 1977; Anglestam et al. 1984; Flowerdew 1985) and (ii) multi-annual cycles witnessed in some species (Henttonen et al. 1989; Hanski et al. 1993).

**Biases relating to habitat** - There are two components to habitat-related biases; firstly, those resulting from differences in the dynamics of the study species in different habitats and, secondly, those relating to differences in trap efficiency in different habitats, mediated through the biases outlined in the previous section. Wood Mice populations in different habitats may behave differently, often as a result of source/sink dynamics and habitat preferences. If such biases influence the number of small mammals caught by trapping, and hence the estimate of abundance, then comparisons between habitats become less meaningful. This might suggest that trapping in different habitats should take place with the data from each habitat used independently to monitor population change. If there is evidence of synchrony between a population sampled in woodland and a population sampled in grassland then this may be taken as evidence of a real population change. However, it is more likely that source/sink dynamics may
result in one population remaining stable while the other decreases, making the true pattern of population change more difficult to detect.

16.3 AVAILABLE METHODS

**Snap-trapping** - Snap or break-back traps kill the small mammals being sampled and careful consideration should be given as to the value and ethics of using them for monitoring purposes. Such traps should always be set undercover and ideally only operated at night to reduce the risk to non-target species. They are considerably cheaper than live-capture traps. Snap-traps have been widely used in the surveillance of small mammal abundance in Scandinavia (Myllymaki *et al.* 1977) through the application of the Small Quadrat Method (SQM).

**Live-trapping** - Live-trapping methods have been reviewed by Twigg (1975), Flowerdew (1976), Tapper (1976) and Gurnell & Flowerdew (1982). Traps can be arranged in grids or lines, the latter being of less value to most small mammal work, but allowing relative changes in catch to be measured and being simpler to operate. A grid approach would ideally involve 49 trap points with two traps per point and an interval of between 5-15m between trap points depending on the target species. Recent work on Yellow-necked Mice by The Mammal Society has employed a reduced grid of two lines of ten trap points with two traps per point. The length of the trapping period should be long enough to catch an adequate sample, but not so long as to introduce bias as assumptions about a closed population begin to break down. Field Voles require a period of 3-4 days prebaiting before the trapping is carried out (Toms, in prep.), although this is less important for other species. The choice of trap is also important with some considerably less effective than others (Toms, in prep., but see Lambin & Mackinnon, 1997). It is important that, for monitoring purposes, a single trap design should be employed, with no mixing of designs between sites. Similarly, the spacing and arrangement of traps used should also be held constant.

**Hair tubes** - Hair tubes have been successfully applied to the study of some small mammal species (e.g. Water Shrew, Mike Jordan; Harvest Mouse, Martin Perrow), although some species cannot be separated through this approach. An additional problem is that the perceived 'abundance' of a species derived from the use of hair tubes, will contain an activity component in addition to the abundance component. Whilst this also occurs when live-trapping, the effect with hair tubes is likely to be more significant. There is some evidence that, at least for Harvest Mice, there is a correlation between hair tube indices and those derived from live-trapping.

**Field signs** - Sign-indices have been derived for the examination of Field Vole populations (Hansson 1979; Village & Myhill 1990). Hansson (1979) found that grazing intensity and to a lesser extent, runways and faeces piles, correlated well with trap catches of *Microtus agrestis* on abandoned fields throughout the year. In forest habitats similar correlations were found between field signs and trap catches of *Clethrionomys glareolus*. Under some circumstances the faeces of these two species can be difficult to separate. Village & Myhill (1990) derived an index based on field signs for *Microtus agrestis* which enabled large differences in population size to be determined (but not necessarily smaller changes). Tapper (1976) used the number of active runways as a measure of abundance, although he also demonstrated this to vary seasonally.
The droppings of *Neomys fodiens* can be distinguished from other shrews (in most cases) because they contain aquatic invertebrate remains and it is possible to collect these droppings from baited feeding tubes or dropping boards at bait stations (Abyes & Sargent 1997). This approach has been used in a national pilot survey examining the habitat preferences of the species (Greenwood 1998). It should be noted that the diet of those Water Shrew populations established away from water may not contain the diagnostic remains of aquatic invertebrates (Churchfield 1990), making this component of the national population more difficult to monitor effectively. Stephen Harris (pers. comm.) feels that this component of the population is likely to be transitory in nature, reducing the importance for its direct monitoring.

**Pellet remains** - The identifiable remains of small mammals found in the pellets of owls may allow changes in small mammal populations over time to be investigated. There are two potential problems with this approach. First, individual owls are not likely to hunt in a random fashion, i.e. they do not take small mammal prey in relation to their availability (Yom-Tov & Wool 1997). This means that the proportions of different prey recovered from pellets are not representative of the proportions of those same prey in the wider countryside (although see Glue 1970). Individual owls may select prey on the basis of its profitability, either directly or through some selection of the habitat over which they choose to hunt. Therefore, this problem relates to how representative the data are of small mammal populations in the wider countryside.

A second problem is that the prey species selected by an owl may change over time; either as a result of a changing prey availability (the target of monitoring) or because of changes in the habitats selected by the owls for hunting. Changes in those habitats selected for hunting may result from changing prey availability, or as a consequence of changes in the owl population itself. At high population densities a component of the owl population may be forced to hunt over sub-optimal habitats, taking a different range of prey species to those occurring in optimal hunting habitats. At low population densities all hunting may take place over optimal habitat, so changes in the proportions of individual small mammal species in owl pellets may result from either (1) real changes in the occurrence of small mammals or (2) changes in the habitats hunted by owls due to the population size of the owls themselves.

Even if individual owls (or owls depositing pellets at individual sites) do not take prey directly in relation to their availability, it may be possible to build up a general picture of large scale trends in small mammal populations by analysing pellet samples from a large number of sites and from different predator species. For example, regular analysis of pellets from Kestrels *Falco tinnunculus*, Little Owls *Athene noctua*, Long-eared Owls *Asio otus* and Barn Owls *Tyto alba* may all point towards a decline in the proportion of Common Shrews being taken, thus providing some evidence that something has happened to either the Common Shrew population or populations of the other small mammal species occurring in the diets of these three species. The potential of this approach has been highlighted by a recent study examining Barn Owl diet in the UK (Love et al., in press), a follow up to the previous national study (Glue 1974), which together show a shift in the proportion of Common and Pygmy Shrews being taken. This may indicate a genuine change in the populations levels of these two species or a shift in the habitats over which Barn Owls are hunting. Either way it is indicative of something happening and as such may provide support to some other monitoring approach to small mammals.
16.4 DEVELOPMENT AND VALIDATION STUDIES

A full protocol should be developed following more detailed discussions and pilot fieldwork, although there are several points that are worth raising here.

1) A period of three days prebait is required when trapping Field Voles (Toms, in prep.).

2) Shrew captures require that traps are visited at least twice a day, increasing to every six hours in extreme weather.

3) All small mammal populations show pronounced annual fluctuations usually resulting in a population peak during late autumn. Trapping should therefore be carried out twice a year (late spring and late autumn) to produce a measure of abundance of value to monitoring.

4) Many small mammal species show pronounced inter-annual fluctuations, with some cyclicity recorded for populations in some habitats.

5) Cyclic behaviour, activity, trap response, population density, etc., all vary between habitats and, with the influence of source-sink dynamics, a large number of sites across a range of habitats need to be covered.

16.5 RECOMMENDATIONS

1) Monitoring of Common Shrew, Pygmy Shrew, Water Shrew, Bank Vole, Field Vole and Wood Mouse should be undertaken as a pilot scheme at a small number of sites using live-trapping and a network of volunteers, co-ordinated by a single professional. The scheme should be evaluated after five years and, if found to be practical, expanded to a level where the power for detection is acceptable for monitoring purposes. We cannot say for certain just how many sites would be required for this purpose, but this is something that could be examined by running simulations from the data collected by Mallorie & Flowerdew (1994). The trapping protocol will need to be determined, but could involve volunteers setting traps for prebait on day 1 (Wednesday), setting for capture on day 3 (Friday evening) and trapping on days 4 and 5 (Saturday and Sunday, taking the grid up on the Sunday).

2) Ancillary data should be gathered through the analysis of predator pellets (Barn Owl, Tawny Owl, Little Owl, Long-eared Owl and Kestrel) collected from as many sites as possible.

3) Pilot studies using hair tubes and field signs should be evaluated in parallel to the live-trapping work in order to determine whether either of these approaches could have a monitoring role.

16.6 MONITORING COSTS

The costs of implementing a monitoring programme based on live-trapping at a sufficient number of sites to provide the required power of detection are outlined below. These are very rough figures designed to give an impression of what is involved rather than to specify particular
sample sizes. The sample sizes required would need to be evaluated through a review process and possible modelling of existing datasets, notably that stemming from Mallorie & Flowerdew (1994).

EXAMPLE ONE - Allowing a period of pre-bait and three days trapping - PROFESSIONAL FIELDWORKERS

ASSUMING - (i) a grid of 49 trap points with two traps per point, with a period of three days prebait, three days trapping and one day for change over, would allow one trained fieldworker per grid.

(ii) two trapping periods a year (one in April and one in September) with each trapping period lasts six weeks, would allow one set of traps to be used at six sites during each trapping period.

(iii) one fieldworker can only operate one grid at a time to allow for the likely distance between sites and the time taken each morning and evening to remove trapped animals, mark and release them.

Based on these assumptions, a single, fully committed fieldworker could cover six different sites during the six-week sampling period. The six-week sampling window is required to ensure that different sites are sampled at a similar time to each other thus reducing seasonal bias. This would mean that:

(i) a sample of 50 sites would take 350 working days per trapping period (700 per year) and require nine fieldworkers using 882 traps (£26,460 for traps).

(ii) a sample of 100 sites would take 700 working days per trapping period (1,400 per year) and require 17 fieldworkers using 1,666 traps (£49,980 for traps).

(iii) a sample of 500 sites would take 3,500 working days per trapping period (7,000 per year) and require 84 fieldworkers using 8,232 traps (£246,960 for traps).

These calculations assume that fieldworkers would be fully committed during the six week period. This would almost certainly rule out volunteer involvement, although a different approach could be adopted to involve volunteers.

EXAMPLE TWO - no period of prebait and two days of trapping. VOLUNTEER FIELDWORKERS

ASSUMING - (i) two rows of 10 trap points with two traps per point, with the traps set on a Friday night and checked twice on the two following days. Allowing one trained fieldworker per grid.

(ii) two trapping periods a year (one in April and one in September) with each trapping period lasts six weeks, would allow one set of traps to be used at six sites during each trapping period.
(iii) one fieldworker can only operate one grid at a time to allow for the likely distance between sites and the time taken each morning and evening to remove trapped animals, mark and release them. Traps would be passed to the fieldworker covering the next site during the intervening days.

Based on these assumptions, six different sites could be covered during the six-week sampling period. The six-week sampling window is required to ensure that different sites are sampled at a similar time to each other thus reducing seasonal bias. This would mean that:

(i) a sample of 50 sites would take 125 working days per trapping period (250 per year) and require a maximum of 50 fieldworkers assuming one fieldworker per site, using nine sets of traps (882 traps) (£26,460 for traps).

(ii) a sample of 100 sites would take 250 working days per trapping period (500 per year) and require a maximum of 100 fieldworkers assuming one fieldworker per site, using 17 sets of traps (1,666 traps) (£49,980 for traps).

(iii) a sample of 500 sites would take 1,250 working days per trapping period (2,500 per year) and require a maximum of 500 fieldworkers assuming one fieldworker per site, using 83 sets of traps (8,232 traps) (£246,960 for traps).

Other alternatives could be considered, varying the number of traps used, the number of sites to be covered, the inclusion of a period of prebait as part of the volunteer approach and the length of the trapping period.

16.7 RECOMMENDATIONS

1) Development of suitable monitoring methods for Common Shrew, Pygmy Shrew, Water Shrew, Bank Vole, Field Vole and Wood Mouse should form part of a specific study. Attention should be given to the value of live-trapping, pellet analysis, field signs and the use of hair tubes. Of these, only live-trapping will allow monitoring of all these species at the same time: field signs cannot be used for the two Sorex spp. or Apodemus, hair tubes likewise, and pellet analysis is best suited for determining broad changes in commonly taken prey species.

2) Volunteer involvement is likely to form the basis for long-term monitoring of these small mammal species, but only with the support of a number of professional co-ordinators, a ready supply of traps and good logistical support.
17. RED FOX *Vulpes vulpes*

Native; common and widespread in Britain and Ireland but absent from most small islands; population may be increasing, especially in urban areas.

17.1 RECENT AND ONGOING MONITORING

**Game Conservancy National Game Bag Census** - Game Bag records from a sample of shooting estates throughout the UK dating back to 1961 (with additional historical records). These data show a continuing, increasing trend which has been interpreted as showing an increasing population (Reynolds & Tapper 1994). The data are subject to severe biases, however, and have not been corroborated: sampling methods have changed over time as has the time of year at which control is typically practised. The sampling method has direct effects on the effort effectively expended, i.e. the combination of the time spent and the efficiency of the method, but the timing of control actions has had potentially even more serious effects by changing the population sampled from resident to dispersing and from older to younger (Reynolds & Tapper 1994). The apparent population increase could therefore be an artefact of changes in the “sampling regime”. Greatly increased inter-annual variation in bag data from recent years (Reynolds & Tapper 1994) gives further cause for concern.

**Long-term monitoring by gamekeepers (The Game Conservancy Trust)** - Over sixty gamekeepers from around the country conduct twice weekly spotlight counts of foxes with, critically, a measure of survey effort. This is a recently established survey, but is intended to run in the long term. Cull data are also collected. To an extent dependent on its geographical and habitat range, this survey could provide an important contribution to the monitoring of rural Red Fox populations.

**Direct distance sampling surveys by spotlight (The Game Conservancy Trust)** - A professional survey to calibrate spotlighting by gamekeepers in four, geographically separated study areas over the period 1995-1997. The survey, using standardised methods, revealed consistent differences between regions which corroborate the gamekeepers’ spotlight counts.

**The National Fox Survey (The Mammal Society/University of Bristol)** - A survey of scat density and replacement rates in rural areas in February and March, 1998-2001, based on up to 1,000 randomly selected 1km squares (a sample stratified by ITE Landscape Region). The aim is to collect scats from along all or at least 5km of the linear features found in the square (scats are then collected centrally for dietary analyses). “Linear features” are defined as hedgerows and other fence lines, roadside verges, worn footpaths or tracks, woodland edges and the banks of ditches, rivers, lakes and other water features. Estimates of the national population and of geographical variations in abundance will be made from the results of the survey.

**Forestry Commission Kill Records** - These records will be geographically limited and may suffer from a lack of effective measures of effort.

**Fox Hunt Kill Records** - Hunt kill records will vary in quality from hunt to hunt, but all will be derived from areas which support high fox populations and which may be managed for them. Hunting effort will be variable and difficult to quantify, and may not be recorded in any form.
Urban foxes - Stephen Harris and others at the University of Bristol have conducted detailed studies of the determinants of Red Fox abundance in British towns and cities which have generated models capable of predicting fox densities in any British conurbation from habitat and sociological data (Harris 1981; Harris & Rayner 1986a,b,c; Harris & Smith 1987). The survey work underlying these models was based on counts of litters and made use of the voluntary participation of schools (Harris 1981; Harris & Rayner 1986a).

17.2 MONITORING OBJECTIVES

The objective may be to measure trends in rural and urban Red Fox populations. Red Fox populations have intrinsic conservation interest, but monitoring may also be important with a view to the effects of hunting and control requirements perhaps, and there may be intra-guild competition issues with respect to Pine Marten. Population information could also feed into policy development for rabies control.

17.3 POTENTIAL MONITORING TECHNIQUES

Spotlight counts - The eyeshine of foxes is distinctive enough for it to be distinguished from that of other similarly-sized animals by experienced observers. Spotlight counts along standardised transects therefore represent a potentially useful survey technique. Counts should be made during February and March, between 2100 and 0300 hrs on clear nights, to estimate spring breeding density. Problems with spotlighting are that it is unsuitable for volunteers (it is labour-intensive, involves unsociable hours and requires considerable training), that counts are likely to underestimate fox populations because the animals learn to avoid lights under shooting pressure (so counts are seriously biased according to the intensity of shooting), that habitat access is severely biased by the need to use motor vehicles and that animals in woodland cannot be seen. Avoidance of lights due to shooting pressure further mean that counts are biased towards recording (young) animals which have yet to be shot at. It is also likely that the lights available for spotlighting will increase in power over time, affecting sampling efficiency (such issues have been considered with respect to improvements in bat detector technology).

Hunting and Game Bag records - Long time series of historical Game Bag and hunting records exist and these data are likely to continue to be collected. These data therefore might provide a valuable historical context for future survey data. However, hunting and bag record data are subject to important biases which severely limit their potential as a front line monitoring method. Game Bag data depend critically on the sampling effort, including the type of method (shooting, trapping or poisoning) and the efficiency of the method, as well as the man-days spent in control measures; these are rarely recorded. Assumptions must therefore be made about the constancy of methods which cannot be tenable in the long term. Bag or hunt records are also likely to be biased towards area of high fox density, so being unrepresentative of low density areas. These problems make bag records a poor monitoring tool for foxes. Game Bag data are discussed in detail in Part III.A.2.

Drive counts - Total populations can also be counted by driving with beaters or dogs. However, considerable effort is required: in this case, teams of individuals for each survey plot.

Fox hunt counts - Fox hunts could provide data on the numbers of foxes seen during hunting, as a crude transect-type method. However, hunts will only go where prior intelligence suggests
foxes will be found, so counts are unlikely to track population abundance, among other problems (see MMR, p. 177).

**Mammals on Roads** - Fox carcasses are among the more easily identified road-deaths, so road-death data could give useful background information on distribution. Given measures of search effort and estimates of traffic density, as postulated for our proposed Mammals on Roads survey (Part III.B.3), information on abundance could also be obtained.

**Live-trapping** - Foxes can be trapped and tagged, allowing population sizes to be estimated by CMR. However, trapping is labour-intensive, costly and time-consuming. It is also especially difficult in rural areas and some individuals are extremely trap-shy (S. Harris, pers. comm.).

**Field signs (faecal counts)** - Fox faeces are easily identified, so volunteers could feasibly be used to collect data, especially after Mammal Society accreditation. The National Fox Survey is effectively providing a valuable baseline measure of rural Red Fox abundance to which future faecal count work can be compared. It will also provide valuable information on the effectiveness of the method and suggest where improvements could be made. Preliminary results indicate encouraging scat detection rates and responses from volunteers (S. Harris, pers. comm.). Fox scats would be a key target of the proposed Sign Transect Survey (Part III.B.2) and would be monitored as part of our proposed survey protocol for Pine Marten, particularly because of the interactions that occur between the two species.

**Field signs (track counts)** - Tracks can be identified and counted, but serious habitat biases and weather effects are likely unless specialised methods (sand traps or tracking plates) are used. Such methods effectively preclude any large-scale volunteer input. A further problem is that the tracks of foxes and small dogs can be difficult to distinguish in less than ideal conditions (S. Harris, pers. comm.).

**Field signs (breeding den counts)** - Several field signs allow the identification of Red Fox breeding dens in spring, especially if dogs are used. Data on abundance could be obtained from standardised searches for breeding dens, but encounter rates are likely to be low per unit search effort and searching could have to be very intensive, using teams of six to eight searchers for a 1km square (see Insley 1977). This may make the method unsuitable for volunteer input.

**Bait discovery** - This method is under development by MAFF and the Game Conservancy Trust and could provide robust estimates of density if the effects of learning can be controlled for. However, it will always be an intensive method for professionals only, requiring repeated visits to baits and standard bait preparation methods.

**Visual transect counts** - Sightings of foxes in daylight are probably too infrequent for monitoring via direct counts from transect surveys such as the Breeding Bird Survey, but presence/absence data based on controlled off-transect sightings and evidence from field signs such as scats could contribute usefully to national fox monitoring (see Part III.B.2). Sighting rates would be higher from winter/early spring transect counts (see Part III.B.1).

**Questionnaire surveys/follow-up litter counts** - This method has been used successfully to measure fox densities in urban areas, which are important yet difficult to survey in similar ways to rural areas. Casual sightings or questionnaire returns from the general public (i.e. not necessarily paid-up wildlife enthusiasts) backed up by professional input provide an efficient way of surveying urban areas.
**Garden sightings** - Red Fox is a key species which can easily be monitored by a garden-sighting based monitoring scheme and whose urban and sub-urban populations are important. Our proposals for a Garden Mammal Watch are detailed in Part III.B.5.

### 17.4 POTENTIAL MONITORING SCHEMES

**MMR Recommended Approach** - Within the QQ grid of 10km squares, MMR suggest that 1km squares should be surveyed for foxes by spotlighting along 1km transects covered by car. They also suggest supplementing this information with scat data collected in conjunction with sign surveys for other species, with questionnaire surveys of landowners and householders and with Game Bag data. We have outlined the major problems with Game Bag data and spotlighting above (see also Part III.A.2): we believe that these methods are unlikely to monitor foxes adequately. Surveys for fox scats fall under our proposed Sign Transect scheme (Part III.B.2).

**Combined, complementary surveys** - We suggest that separate survey approaches are required for urban and rural Red Foxes. For urban foxes, there are two options: regular questionnaire surveys (perhaps using school projects) backed up by professional checks for litters, using the work of Stephen Harris (Harris 1981; Harris & Rayner 1986a) as a model, or a less specific approach using records from a Garden Mammal Watch (see Part III.B.5). Recent changes in the UK’s educational culture such as the development of the National Curriculum may limit the extent to which repeats of Harris’ school-based work is practicable (S. Harris, pers. comm.). The latter might not monitor animals in more urban areas well, but should detect large changes in sub-urban populations. The regular questionnaire approach could target a random sample of urban areas and the sample could be rotated according to, say, a five-year cycle to maintain interest and broaden participation. Such a survey could have an additional benefit of introducing children in urban areas to wildlife and conservation issues.

For rural foxes, we suggest that a scaled-down version of the National Fox Survey would provide the best guide to changes in abundance and distribution. Such a survey would be provided by our suggested Sign Transect Survey (see Part III.B.2), within which Red Fox would be a key species. Scat numbers vary with diet (S. Harris, pers. comm.), so some periodical checks for changes in diet (say, using faecal analysis) would be necessary as controls to prevent misinterpretation. Ancillary information on fox abundance and distribution would also be forthcoming from the Breeding Bird Survey (see Part III.A.1) and our proposed Winter (visual) Transect Survey (see Part III.B.1). These surveys will be subject to different biases to those affecting sign transects, so would provide an independent check on the results. Mammals on Roads (Part III.B.3) could also contribute and further field sign data would be collected in the course of transect surveys for Pine Marten in habitats where the species co-occur (see Pine Marten species account).

### 17.5 RECOMMENDATIONS

1) For urban foxes, it may be considered that a specific monitoring scheme is unnecessary, in which case we recommend that a Garden Mammal Watch (see Part III.B.5) be set up, within which Red Fox would be a key species. This should detect large changes in urban and suburban fox range and abundance.
2) For rural foxes, we recommend that our proposed Sign Transect Survey (see Part III.B.2) forms the principal monitoring tool for the species. Using the National Fox Survey results as a baseline, this will provide information on changes in range and abundance. We suggest that visual counts of foxes from the Breeding Bird Survey (Part III.A.1) and a Winter Transect Survey (Part III.B.1) will also contribute valuable information, as will Mammals on Roads.
18. PINE MARTEN *Martes martes*

Native. Population largely restricted to Scotland and currently recovering from a dramatic population collapse in the mid-Nineteenth Century. Several satellite populations appear to exist in England and Wales, although their viability has been questioned (Langley & Alden 1977; Bright & Harris 1994).

18.1 RECENT AND ONGOING MONITORING WORK

**Lockie (1964)** - Lockie (1964) examined the distribution of Pine Marten records in Scotland, based on the submission of sightings and trapping records. Local fluctuations in numbers were also studied at Beinn Eighe NNR, Wester Ross, providing evidence that there is a seasonal pattern to the occurrence of scats. This was demonstrated at least partially to be the result of differences in the rates at which scats disintegrated with season. Scats disintegrated more quickly in summer than in winter and Lockie was able to apply correction factors to his index of Pine Marten abundance.

**Vincent Wildlife Trust Survey (1981-82)** - Fieldwork, undertaken by a single fieldworker over 18 months, was based on transects recording the occurrence of Pine Marten faeces at 277 sites (Velander 1983). Two hundred and sixty people were interviewed regarding records of Pine Martens and 65% of reported sightings were followed up by site survey to verify reliability. A similar approach was adopted in the Republic of Ireland (O'Sullivan 1983). Positive records were noted from 155 10x10km squares. Fieldwork effort was concentrated towards the main Scottish population, although the work carried out in England failed to reveal any direct evidence of Pine Marten populations. Velander (1983) concluded that Pine Martens were still present in at least some of the satellite areas on the basis of local reports. It has been suggested that the method employed by Velander did not have a large enough sampling intensity to successfully locate Pine Martens at the very low population levels at which they are thought to occur in England and Wales (Don Jefferies, pers. comm.).

**NCC Pine Marten survey of England and Wales 1987-1988** - Similar survey methods to those employed by Velander (1983) were used in a NCC study of Pine Marten populations in England and Wales. Sightings were gathered from a range of sources, these being used to identify 'core' areas where fieldwork should be carried out. Additional effort was targeted to those adjacent sites that contained 'likely' habitat. The fieldwork employed again involved transect sampling for field signs, although the sampling intensity used was increased over that used by Velander (1983). Fieldwork was carried out over a 19 month period by a single observer. Because of this, effort was directed to sites selected for the likely presence of Pine Martens, rather than on the basis of random selection.

Selected sites were resurveyed at a different time of year to (a) investigate those areas where available information suggested that martens were present but had not been detected, and (b) check on possible seasonal variation in either the ability to detect martens, their marking behaviour or in the use of certain areas for food resources (Strachan *et al.* 1996). Because the 2km survey transects were chosen as likely positive sites, the number of survey sites examined per 10x10km square depended on the extent of apparently suitable habitat within that square. The survey found a mean density of 6.22 sites per 10x10km square (range 1-22). Three potential problems arise with the methodology especially when applied to Pine Marten populations occurring at low density:
(a) Pine Martens may alter their range at different times of year;
(b) Seasonal movement within established ranges may occur;
(c) Seasonal variation in the deposition of scats may occur.

The survey concluded that although all five of the main populations south of Scotland were still extant in 1988, they all existed at very low densities, with three at least contracting. Scats were only found in four of these regions (Northumberland, Cumbria, North Yorkshire and north Wales). Bright & Harris (1994) note that the partial resurvey of sites by Strachan et al. (1996) did not yield results consistent with the initial visits, and that only 8% of the 896 survey sites yielded positive results.

**Ulster Wildlife Trust and Forest Service Study** - A questionnaire approach was adopted in 1993 by the Department of Agriculture for Northern Ireland (DANI) Forest Service and the Ulster Wildlife Trust (Hughes 1993). A recording sheet was distributed through forest officers and other staff responsible for the various forest management units throughout Northern Ireland. Reports suggested a westerly distribution for this species, although there are likely to be difficulties in interpreting this type of data, given the habits of (Pine Martens).

**English Nature study** - Bright & Harris (1994) examined the feasibility of reintroducing the Pine Marten into parts of its former range. As part of this work, 91 2km transects were walked at a number of sites from the previous survey with the express purpose of determining whether marten populations were present. Scats were readily located on transects near Glen Trool, Galloway, but only two Pine Marten scats were positively identified from transect counts carried out elsewhere. The authors concluded that ‘..Pine Martens are on the verge of extinction in England. There is no viable population in Cumbria, nor almost certainly in north Yorkshire.’ Comments from this work also serve to highlight the overlap in scat shape between Pine Martens, other mustelids and Foxes. This is supported by ongoing DNA analyses of faecal material, which ‘..casts doubt on the validity of any survey technique based on scats alone.’ (Angus Davison, pers. comm.). It should be noted that surveys in the Lake District in 1993 and in North Wales in 1994, suggest that there have been further significant declines in numbers (Bright et al., unpublished).

**Scottish Natural Heritage Report (1994)** - The survey work undertaken by Balharry et al. (1996) again utilised a two-tier approach, questionnaires and 1km transects. Effort was targeted to determine the expansion of the Pine Marten population from 'core' areas, with fieldwork restricted to those areas containing adequate woodland cover (see Balharry 1993). The questionnaire generated 256 returns on the presence or absence of Pine Martens with 620 grid references, covering 42% of the 10km squares in Scotland.

For the fieldwork component, four separate 1km transects (non-randomly selected) were walked in each area, with both Red Fox and Pine Marten scats being collected: those not identified were classified as unknown. The 82 areas searched revealed 404 Pine Marten scats, 754 Red Fox scats and 653 unknown scats. The results demonstrated that there was no significant difference in the frequency of scat deposition per kilometre of track walked between February and September.
The results suggest that marten had recolonised parts of northern and western Grampian, Tayside, Central and Strathclyde regions.

**Vincent Wildlife Trust** - MMR note that the VWT continue to record details of Pine Marten sightings from England and Wales. As part of this work, detailed DNA analyses are being carried out on specimens sent in. During the last couple of years six specimens have been received from England and Wales, 20 from Ireland and over 40 from Scotland (Birks et al. 1997; Angus Davison, pers. comm.). Continued monitoring of the genetics of specimens can also be used to establish the presence of American Martens *Martes americana* and Beech Martens *Martes foina*, both of which have escaped from UK fur farms (Baker 1990; Don Jefferies, pers. comm.).

### 18.2 MONITORING OBJECTIVES

Despite repeated surveys, there remains uncertainty over the status of Pine Marten populations in England and Wales. There is some suggestion that Pine Marten populations are able to persist at very low population densities (Don Jefferies, pers. comm.) possibly indicating that 'relict' populations may remain undetected for long periods. Isolated populations of this species should be a priority for monitoring, alongside work examining the recovery of the Scottish population and some monitoring within the 'core' range to detect future changes.

### 18.3 POTENTIAL MONITORING TECHNIQUES

**Live-trapping** - Pine Martens can be trapped using mesh traps, baited with raw fish or chicken. Traps should be set in areas of suitable habitat and checked daily, with trapping taking place between August and February to avoid trapping heavily pregnant females or those with dependent young (Bright & Harris 1996). Low rates of capture are to be expected, especially where population densities are low.

**Direct counts** - MMR note that sightings may provide information on the presence of Pine Martens within an area, but these would need careful evaluation. Direct sightings, followed up by intensive fieldwork have formed the basis of most Pine Marten survey work within the UK and Ireland.

**Camera traps** - Baited camera traps are recommended by MMR as a means by which the presence of Pine Martens in an area can be confirmed following the receipt of sighting records.

**Road-kills** - Although only small numbers of Pine Martens are killed on the road, road-kills can provide useful data on distribution, physiology and the genetic structure of the population.

**Field signs (faecal counts)** - Fresh Pine Marten scats typically have a characteristic smell, although this is lost as the scats age. To some extent, older scats can be identified on the basis of size and shape, although they are very variable and they overlap in size with Stoat at one end and Fox at the other. Shape is highly dependent on diet. Additionally, confusion may occur with Ferret and Mink scats. Scats are deposited along man-made tracks (usually dirt or stone, but not grass) and transects along these tracks (at least 1-2km in length) have been used for monitoring purposes. Work by Balharry et al. (1996) showed for areas with resident breeding Pine Martens that they would be '..unlikely to find no scats if at least 2km of track [were] walked..' and that '..we can be 95% confident of finding four or more scats if we walk at least 3km of suitable track and seven or more if we walk 4km..'. In areas with low population densities or containing only transitory individuals, the degree of scatting is likely to be greatly reduced, making it difficult to
apply a transect approach based on field signs. Territorial behaviour in other mustelids has been shown to break down altogether at low population densities potentially making this method ineffective in some regions (Lockie 1966).

**Field signs (tracking-stations)** - Baited tracking stations have been used for a range of mustelid species (e.g. King & Edgar 1977) and the potential exists to employ their use in a similar manner to hair tubes and camera traps. All three methods should be evaluated during a pilot study carried out at various sites within the known Pine Marten range.

**Hair tubes** - The value of hair tubes is currently being evaluated by the Vincent Wildlife Trust. These would seem to be more cost-effective than live-trapping for the purposes of determining the presence of Pine Martens within an area, although their reliability needs to be established.

**Mammals on Nature Reserves** - Records of Pine Martens on nature reserves could be collated according to the suggestions outlined in Part III.B.6.

**Garden Mammal Watch** - Pine Martens may use some gardens within their Scottish range and it would be useful (for both the collation of distribution data and project profile within Scotland) to include Pine Marten on the list of mammal species to be covered by this scheme (see Part III.B.7).

### 18.5 POTENTIAL MONITORING SCHEMES

The 'core' Pine Marten population (with its front of range expansion) and the 'relict' populations in England and Wales should be treated in different ways. Primarily this relates to the different monitoring objectives for these areas, although apparent differences in population density would also require the use of different approaches for the different areas.

**'Core' populations and front of range expansion** - Sites within these areas should be monitored on a regular basis every five to seven years. Suitable habitat, as defined by Balharry (1993) and Balharry et al. (1996) should be surveyed within a grid of survey squares selected from the existing range in Scotland and those areas bordering the front of range expansion. The same sites should be revisited during subsequent surveys, thus providing a continuous dataset on range expansion and colonisation rates, together with the statistical benefits of repeat surveys at the same sites. Trained volunteer fieldworkers should walk 2-3km along predetermined transects, located along paths, rides and tracks within suitable habitat. All field signs (Pine Marten, Red Fox and unknown) should be recorded and collected, allowing the potential for validation work by experts or DNA analysis at a later stage. Fieldwork should be undertaken during the period when territories are thought to be most stable (February to September) and co-ordinated by a number of local organisers under the direction of a single scheme co-ordinator, presumably based at SNH. This approach would also allow the monitoring of Red Foxes within Pine Marten habitat, something that is considered important given the perceived interactions between these two species (Don Jefferies, pers. comm.). Information from other sources (e.g. road-kills) should be fed into the monitoring programme enabling the addition of new survey squares on a rolling basis, as the population continues to expand.
'Relict' populations in England and Wales - The status of 'relict' populations should be the target of focused work, with known sightings and other distribution records being followed up by intensive fieldwork using either live-trapping, camera traps, hair tubes or tracking boards, rather than field signs. In areas where Pine Martens are found to occur, there is the possibility of more detailed work (funded as separate projects) to ascertain population density, habitat use and likely population change.

Co-ordination of Pine Marten monitoring is likely to require the part-time involvement of single individuals each based at one of the four country agencies. These individuals would liaise at the national level ensuring that national work is consistent. It is thought that some professional fieldworkers would be required on a seasonal basis to undertake fieldwork when required.

18.6 RECOMMENDATIONS

1) The 'core' population and its expansion should be monitored every five to seven years using a grid of survey squares containing suitable Pine Marten habitat. These should be surveyed by trained volunteers, supported by professionals, to carry out transect counts of field signs. Transects should follow tracks and paths as detailed by Balharry et al. (1996) and be of 2-3km in length. Red Fox field signs should also be recorded along with those of unknown origin. A subset of collected field signs can then be examined by professionals to validate the survey results. Monitoring of the Red Fox population within areas of Pine Marten habitat would also be possible, and is desirable given the potential interactions between these two species.

2) The 'relict' populations in England and Wales should be monitored in greater detail, with recent sightings and other records being followed up by intensive fieldwork based on either live-trapping, camera trapping, hair tubes or tracking boards rather than field signs.

3) Work should be undertaken within the known Pine Marten range to evaluate the effectiveness of hair tubes, live-trapping, camera traps and tracking boards. This should be a priority, enabling application of these techniques to recommendation (2).
19. STOAT *Mustela erminea* and WEASEL *Mustela nivalis*

Stoat - Native. Widespread, major reduction in population size following the outbreak of myxomatosis in Rabbits. Population has recently undergone a partial recovery and reanalysis of Game Bag records, with trapping effort taken into account, suggests that the population is currently stable.

Weasel - Native. Widespread, population boomed after myxomatosis outbreak among Rabbit population. Game Bags indicate a decline since the early 1960s, but see McDonald & Harris (in press). Pronounced short-term fluctuations in some areas in response to availability of small mammal prey (Tapper 1979).

19.1 RECENT AND ONGOING MONITORING WORK

**Game Conservancy National Game Bag Census** - Potential conflicts between Stoats/Weasels and gamebird populations have led to their control on the majority of shooting estates (Day 1968; Moors 1975; Tapper 1976, 1992). Data submitted by gamekeepers on the number of Stoats and Weasels killed annually have, since 1961, been collated through the National Game Bag Census (Tapper 1992). Most of these will have been caught in tunnel traps, although a significant portion of the Stoats will have been shot.

Analysis of these data (Tapper 1992) suggests that the Stoat population underwent a period of recovery (through to 1976) as the Rabbit population recovered from the effects of myxomatosis. Since this time, the national Game Bag trend suggests a gradual population decline.

Game Bag data demonstrate two periods during the year when the number of Weasels trapped reaches a peak (March/April and August/September), with short-term annual fluctuations also evident, as Weasel populations respond to changes in the availability of Field Voles (Tapper 1979). The long-term trend in these data suggest a decline in the number of Weasels killed since 1961.

19.2 MONITORING OBJECTIVES

The monitoring of Stoat and Weasel populations is considered as being of High/Medium priority by JNCC; a result of our relatively poor understanding of the status and current population trend of these species (Paul Rose, pers. comm.).

19.3 POTENTIAL MONITORING TECHNIQUES

**Live-trapping** - Live-trapping would allow the population census (at least of trappable individuals) and estimation of population size through Capture-Mark-Recapture (CMR) techniques (Cross *et al.* 1998). However, individual Stoats and Weasels can show selective responses to trapping, notably relating to sex (King 1975a; Buskirk & Lindstedt 1989), territory size, weather, activity and social status.

Stoats are very active and highly susceptible to damp and nervous exhaustion (King & Edgar 1977). Wooden, rather than metal or mesh traps should be used. A design (the Edgar Stoat
Live-trap) is shown in King & Edgar (1977). The effects of trap position have been evaluated by Dilks et al. (1996).

Traps, set for at least four nights in a linear feature, should be baited with a dead mouse or chick and the entrance smeared with Rabbit gut. Traps will be most successful if operated during the mating season. Erlinge (see King & Edgar 1977) noted that, depending on population density, somewhere in the order of 30-40 hectares need to be trapped for each Stoat observed. If a CMR approach is applied then as much as 200 hectares may need to be covered with sufficient density of traps. This may require a significant amount of fieldwork effort to ensure that the traps are checked regularly (King 1975a, b).

Trapping for Weasels is most effective during the months of July and August (Rust 1968), with the traps themselves positioned along natural runways in hedgerows and ditches or, in the case of traps set in woodland, along specially-created features. Approximately one trap per 0.7 hectares is the spacing recommended by King (1973). Weasels can be trapped in a range of trap designs including wooden treadle traps, but should not be caught using traps made from wire mesh since Weasels chill readily and may damage their teeth on the mesh (King 1973).

From the published literature it appears that the only safe and humane way to handle live mustelids in the field is anaesthetisation (King 1973), although a method has been developed to mark Polecats without doing this (Birks 1997).

**Kill-trapping** - Kill-trapping, using tunnel traps, will provide an index of numbers caught per unit effort. However, it suffers from the same selectivity problems as seen for live-trapping. Additionally, there are other disadvantages, not least that you are killing a component of the population you are supposed to be monitoring as well as other non-target species (Hewson 1972). The removal of individuals from a population may stimulate a response in those untrapped individuals remaining, leading to a disruption of social status and dispersal behaviour. By removing territory holders a sink is created into which other individuals will move, changing the sampling of individuals from within a defined area to sampling over an unknown area. This is not ideal for monitoring purposes. King & Edgar (1977) recommend that to estimate population change by kill-trapping, a single straight line of traps, spaced at 400m intervals, should run for at least 16km through homogenous habitat (i.e. 50 traps).

**National Game Bag Census** - Essentially this approach is a form of kill-trapping, although there are clear differences in the way traps are employed by different gamekeepers, increasing variance in sampling protocol. There is currently no measure of trapping effort, making comparisons over time and between areas somewhat difficult. The value of using trapping records to monitor populations of Stoats and Weasels has been examined by McDonald & Harris (in press) who show that these records can be misleading if sampling effort is not controlled for. They found that the national decline in the numbers of Stoats trapped (Tapper 1992) was equally consistent with a reduction in trapping effort and a true population decline. Such long-term changes in trapping effort are quite likely to have occurred alongside changes in game rearing practice. There is also the question of whether Game Bag data are representative of populations in the wider countryside (see Part III.A.2).

**Tracking** - Tracking methods have been evaluated by King & Edgar (1977), with methods typically employing tracking stations (tunnels) containing an arrangement on the floor to record...
the tracks of visiting individuals. This approach provides a basic index of population status (i.e. proportion of tracking stations containing tracks of the study species), but this index is confused by an activity component. Because of differences in activity, one individual may visit many stations or many individuals may visit only one station, thus providing a false picture of population size. MMR recommend that tracking stations should have an entrance diameter of 8cm and should be placed in natural runways along linear features (as for live- and kill-trap placement). This approach is less-suited to habitats lacking linear features, notably upland areas. Additionally, poor weather can dramatically reduce the efficiency of tracking methods.

**Hair tubes** - Hair tubes are similar to tracking stations in that they record information on both population status and activity. This approach will not separate Stoat and Weasel (Stephen Harris, pers. comm.).

**Camera traps** - MMR note that these traps could be used to record animals running through tunnels. As with some of the other methods already mentioned, an index of population status may be confused by activity patterns, unless individuals can be identified. Individual Weasels can be identified in the hand (Linn & Day 1966) although this approach is not applicable to the current design of camera traps. It should also be noted that camera traps are expensive.

**Field signs** - Because of considerable overlap in faeces size and composition with other species, the use of field signs is not recommended. Additionally, the faeces are difficult to find.

**BBS transect approach** - (see Part II.A.1. - Mammal Monitoring under the Breeding Bird Survey). The presence of Weasels is reported from about 3-4% of BBS squares for which mammal recording forms are submitted annually, while the corresponding figure for Stoats is about 5% of BBS squares submitted annually. However, although Stoats and Weasels are thought to be widespread, they are unlikely to be encountered by fieldworkers even when present in an area. This means that there will be a strong stochastic component to the data submitted by BBS, making it unlikely that the scheme in its current form could be used for monitoring Stoat and Weasel populations. There may be the potential for BBS (or a modified mammal transect scheme) to provide ancillary data, but this requires further evaluation.

**Winter Transects** - (see Part III.B.3) - Compared to summer transects, the encounter rates may be increased through specific mammal visual transects operated during late winter (Stephen Harris, pers. comm.). Again, there may be a significant stochastic component in the data collected. Transects are likely to be a good monitoring technique (Stephen Harris, pers. comm.)

**Sign Transects** - Transects for field signs are likely to be impractical for this species, given the difficulties in separating the scats of small mustelids.

**Mammals on Roads** - The number of Stoats or Weasels recorded dead or alive on the road along regular survey routes could provide a basic index of population change (see Part III.B.5).

### 19.4 POTENTIAL MONITORING SCHEMES

For both species MMR recommend the use of camera traps at a minimum of 2,000 sites, calibrated by live-trapping at a subset of these sites. This is likely to be an extremely expensive option, given the equipment involved and the number of professional man-hours required. A far
cheaper approach would be to develop the information gathered by the Game Conservancy's National Game Bag Census. As noted by McDonald & Harris (in press) this would require some measure of trapping effort to be recorded alongside the trapping returns. If this becomes possible, then Game Bag data may be available from the majority of estates contributing to the National Game Bag Census. There are other problems with Game Bags (see Part III.A.2), the most important of which (for future monitoring of Stoat or Weasel populations) is that changes in legislation regarding the control of the species' or game rearing in general may radically alter the amount of data contributed. The likelihood of such changes occurring must be considered in the context of the likely benefits of utilising the Stoat/Weasel Game Bag data at least over the short term.

Ancillary data for Stoats and Weasels may be obtainable from the BBS, road-kills and road-sighting surveys. These may not provide as detailed picture of population change, but taken together may satisfy the monitoring needs for this species. The use of hair tubes to monitor population change/activity could also provide useful monitoring data, although the feasibility of utilising this approach needs to be evaluated. Co-ordination of the road-based schemes should be carried out by a single individual, also responsible for co-ordination and development of other national schemes (see Parts III.B.2 and III.B.3).

19.5 RECOMMENDATIONS

1) Seek modification of the National Game Bag Census to allow recording of trapping effort, thus enabling trapping returns to be expressed per unit effort. This could form a readily applied and relatively cheap monitoring option. Monitoring of Weasels should take place on an annual basis to allow for the short-term fluctuations that result from variations in Field Vole populations (Tapper 1979).

2) Further evaluate the use of transects for monitoring purposes, notably the data generated by VWT and initially analysed by Simon Poulton.

3) Ancillary data for both Stoat and Weasel could be gathered through the Mammals on Roads scheme (Part III.B.5).
20. **POLECAT *Mustela putorius***

Locally common throughout Wales with populations recorded in 12 to 15 counties within England. Population and range appear to be expanding.

20.1 **RECENT AND ONGOING MONITORING**

**National Game Bag Census** - The National Game Bag Census has a small amount of data (from 31 estates) on the numbers of Polecats shot by gamekeepers, although the species was not specifically added to the National Game Bag Census record until 1997 (Tapper 1992). The inclusion of the species on Schedule 6 of the Wildlife and Countryside Act means that even fewer records are now received. There is also potential confusion between Polecats and Feral Ferrets.

**Vincent Wildlife Trust survey** - Live-trapping was undertaken in selected 1km squares within a sample area covering 58 10km squares. The distribution of sample sites was not random, but selected for convenience of volunteers recruited through the Wildlife Trusts. The criteria used for selecting squares were (1) that they lay within the known range, (2) that they were predominantly rural and (3) that they avoided areas of ground-predator control. Trapping was carried out during the winter (1993-1996). Baited single-entry cage traps were used with each 1km square containing 16 traps set for seven consecutive nights. Volunteers were trained and initially accompanied by an expert. Eight thousand, seven hundred and twenty trap nights resulted in 96 captures of 76 individuals.

**Road-deaths** - Small numbers of Polecats are killed annually on the roads. These reports currently provide important distribution information and contribute to the monitoring of introgression between Feral Ferret and Polecat (see below).

**Genetic Monitoring** - Ongoing work on carcasses submitted to the Vincent Wildlife Trust is examining the introgression occurring between Feral Ferret and Polecat.

20.2 **MONITORING OBJECTIVES**

The restricted distribution of the Polecat together with its gradual colonisation of 'fringe' areas points to a targeted monitoring programme rather than its inclusion in part of a wider scheme. The low densities at which this species occurs (Blandford & Watson 1991; The Populations Review), and the range of habitats it occupies, makes it difficult to monitor without the commitment of significant resources. Distribution monitoring is a high priority as is the collation of detailed information on habitat preferences and the degree of hybridisation with Feral Ferrets.

20.3 **POTENTIAL MONITORING TECHNIQUES**

**Live-trapping** - Polecats can be captured using single-entry cage traps baited with a dead-day-old chick. Each 1km square to be trapped should be divided into a grid of 16 250x250m cells with one trap placed within each cell. These should be left for seven consecutive nights with the bait being replaced on day four. Trapping should be carried out between October and March, a time of year when the Polecat population is likely to be stable. Although labour-intensive, Birks
(1997) has shown that with training volunteers can operate the trapping grid and weigh, mark and release trapped Polecats without sedating them. The number of individuals caught per unit effort is low (0.01 captures per trap night) suggesting potential motivational problems in areas where Polecats are scarce.

**Game Bags** - As noted above, this approach is unsatisfactory for monitoring purposes. A recent questionnaire based study, centered on the main Polecat range, demonstrated that 88% of gamekeeper respondents had experience of Polecats (Packer & Birks, 1999).

**Indirect counts** - Identification of scats and tracks is difficult, making them unreliable for monitoring purposes. Additionally, there may be variation in scatting activity between seasons, habitats and population density as demonstrated for other mustelid species. Hansen & Jacobsen (1999) have demonstrated that faeces of Otter, Mink and Polecat can be separated using DNA analysis, although this approach would probably be prohibitively expensive for monitoring purposes.

**Road-deaths** - As MMR note, this technique is useful for monitoring the distribution and spread of this species. If carcasses are collected then they can be analysed using DNA extraction techniques to monitor the introgression between Ferrets and Polecats.

**Mammals on Nature Reserves** - Records of Polecats on nature reserves could be collated according to the suggestions outlined in Part III.B.6.

### 20.4 POTENTIAL MONITORING SCHEMES

A targeted monitoring programme concentrating on the boundary of the core range would appear to be the most cost-effective way in which to monitor the increase in range of this species. Other work should be undertaken within the core range to monitor any future impacts that may influence the population. Significant resources need to be committed to the monitoring of this species, given that intensive live-trapping is the only workable option. The approach outlined and tested by Birks (1997) should be used as the basis for future work and costs of fieldwork based on this approach, mixing a single professional organiser with volunteer fieldworkers.

### 20.5 RECOMMENDATIONS

1) Live-trapping of this species should be undertaken both within the core range and along the boundary of its current range expansion. This should follow the protocol outlined by Birks (1997).

2) Material removed from trapped animals, along with that from road-kills, should be analysed to determine the degree of introgression between Feral Ferrets and Polecats. This is currently being investigated by the Vincent Wildlife Trust.

3) Ancillary data may be available from the Mammals on Nature Reserves and Mammals on Roads schemes within the current range, although these alone may not be of sufficient detail or quantity to provide adequate monitoring for this species.
21. FERAL FERRET *Mustela furo*

Escaped individuals can be encountered across the UK making it difficult to detect established feral populations. Island-based feral populations have occurred on Mull, Lewis, Bute, Arran and the Isle of Man (Blandford & Walton: in The Handbook), Shetland, Islay, Harris, Mull and The Uists (The Populations Review).

21.1 RECENT AND ONGOING MONITORING

None.

21.2 POTENTIAL MONITORING TECHNIQUES

**National Game Bag Census** - Feral Ferrets are likely to be controlled on shooting estates as part of the general management of mustelid predators (Tapper 1992). Although the National Game Bag Census does not currently report on the number of Feral Ferrets killed annually by gamekeepers, the scheme could do so in the future. Confusion with the legally protected Polecat may reduce the number of individuals reported in some areas.

**Vincent Wildlife Trust Polecat survey** - Feral Ferrets may be caught during the live-trapping of Polecats providing some data on the occurrence of this species (see Polecat).

**Road-deaths** - Small numbers of Feral Ferrets are likely to be killed annually on the roads. These reports could provide important distribution information and contribute to the monitoring of introgression between Feral Ferret and Polecat (see below).

**Genetic Monitoring** - Ongoing work on carcasses submitted to the Vincent Wildlife Trust is examining the introgression occurring between Feral Ferret and Polecat.

**Breeding Bird Survey/Winter Transects/Garden Mammal Watch** - Although they are rarely encountered, validated reports of Feral Ferrets could contribute some ancillary information on distribution. However, it would not be possible to monitor population trends effectively by these methods.

21.3 MONITORING OBJECTIVES

The Ferret is an introduced species, fully interfertile with the Polecat and established in some areas. Information is needed on this species because of its potentially deleterious effects on native fauna. This is twofold:

- Competition and hybridisation with Polecats on the mainland.
- Predation, on islands from which Polecats are naturally absent.

We suggest that this leads to four monitoring objectives

- To determine trends in the frequency of occurrence of Ferrets at liberty on the mainland.
- To detect the establishment of Feral Ferret populations on the mainland.
• To report on occurrences of Feral Ferrets at liberty on islands which have no established populations.
• To establish trends in abundance of Feral Ferrets on islands on which they are currently established.

21.4 POTENTIAL MONITORING SCHEMES

The presence of escaped individuals over such a large area makes it difficult to monitor the general status of this species in mainland Great Britain. Information on the occurrence of Feral Ferrets should be gathered using all available schemes (e.g. road-kills, Garden Mammal Watch, Winter Transects, Polecat studies, etc.). If the National Game Bag Census is to be used in the monitoring of other mammal species, then it may be worthwhile asking estates to report on the numbers of Feral Ferrets killed annually.

Populations of Feral Ferrets established on islands could be monitored using a live-trapping approach similar to that devised for Polecat (see Polecat species account), although the density and ranging behaviour of ferrets on these islands may differ. Trapping for monitoring purposes should be considered alongside trapping for removal purposes.

21.5 RECOMMENDATIONS

1) Distribution data on Feral Ferrets should be gathered through other single species or multi-species schemes wherever possible.

2) The value of trapping island populations for monitoring, rather than for control should be considered before any decision to monitor such populations is made.

3) The National Game Bag Census should be extended to allow submission of records of Feral Ferrets.

4) Analysis of carcasses to examine introgression between Feral Ferret and Polecat should continue through work co-ordinated by the Vincent Wildlife Trust.
22. AMERICAN MINK *Mustela vison*

The American Mink population has been undergoing a general expansion in range and numbers across the UK, although recent evidence suggests that many populations are in decline, probably as a result of competition with a recovering Otter population.

**22.1 RECENT AND ONGOING MONITORING WORK**

**Department of Agriculture and Fisheries for Scotland Enquiry** - An enquiry into the changing status of American Mink in Scotland was carried out using data from mink farmers, gamekeepers, museums, naturalists, Government Pest Officers and Department of Agriculture trapping records. This analysis demonstrated the rapid spread of American Mink since the early 1960s and suggested that the existence of suitable habitat and abundant food supplies would allow further expansion in numbers and distribution (Cuthbert 1973).

**Forest & Wildlife Service Enquiry** - Data on the status of American Mink throughout Ireland (including Northern Ireland) were gathered from all available sources as part of an enquiry undertaken by the Forest & Wildlife Service. This information was supplemented by a survey carried out between 1984 and 1986. Trained fieldworkers visited selected 10km squares and walked a minimum 3km length of representative rivers, recording field signs of both American Mink and Otter (Smal 1988). Some 167 of the 312 watercourses surveyed (53.5%) showed the presence of American Mink. It should be noted that there were variations in the amount of effort expended in each square, and that this may have introduced some bias to the overall results.

**Vincent Wildlife Trust National Otter Surveys** - Field signs (scats) of American Mink have been recorded during each of the three Otter surveys carried out in England. The reports on these surveys (Lenton *et al.* 1980; Strachan *et al.* 1990; Strachan & Jefferies 1996) contain maps highlighting those 10km squares (within the survey grid) with American Mink present. Examination of the data suggests a continued expansion of the American Mink population into the Midlands and south-east England, with evidence of a decline in the south-west most probably linked to the recovering Otter population (Strachan & Jefferies 1996). During the initial survey, recording effort along the 600m transects was terminated once signs of Otters were found and this may have resulted in some stretches containing Mink not being recorded as positive sites, simply because the Mink field signs had not been reached in the linear transect. Transect length would have varied between sites depending upon the distance at which Otter spraints were found, thereby introducing an element of spatial bias into the Mink dataset in terms of sampling effort.

**Vincent Wildlife Trust Water Vole Survey 1989/1990** - Evidence of American Mink was recorded as a component of the VWT Water Vole survey, enabling the distribution of this introduced species to be determined nationally. One thousand and twenty-two (34.4%) of the 2,970 sites examined for Water Voles showed evidence of American Mink presence (Strachan & Jefferies 1993).

Environment Agency - The Environment Agency's 'River Habitat Survey' documents the presence of American Mink in conjunction with the collation of data on habitat and river features. Additional training may be needed to ensure that RHS recorders can identify field signs (see Part V).

Wildlife Trusts and other organisations - A number of projects examining the status and distribution of American Mink are being carried out nation-wide, many as components of projects on Otters and Water Voles.

22.2 MONITORING OBJECTIVES

The American Mink was first recorded breeding in the wild over 30 years ago, since when it has become an established part of the UK fauna (Birks 1990). It is only recently that researchers and policy makers have begun critically to examine the effects of its establishment (Birks 1990; Woodroffe et al. 1990). Consequently, there is a clear need to undertake detailed monitoring of the distribution, status and likely impact of the species within the United Kingdom. Specifically, information should be gathered by:

a) monitoring the distribution and spread of American Mink within individual catchments, especially where catchments contain populations of Water Voles or Otters;

b) monitoring how the distribution and abundance of American Mink is changing in relation to recovery in the Otter population and loss of Water Vole populations. If data can be gathered relatively easily and cheaply (possibly as a component of other work) then examination of the interactions between American Mink, Otters and Water Voles may be possible.

c) monitoring the distribution and abundance of American Mink on islands where they may constitute a threat to seabird colonies or other wildlife.

This would suggest that monitoring should be carried out through the proposed national Otter and Water Vole surveys.

22.3 POTENTIAL MONITORING TECHNIQUES

Live-trapping - American Mink can be trapped in commercially available baited traps (Dunstone 1993). These should be positioned close to the water's edge with the entrance facing downstream and some degree of camouflaging employed. Traps can be positioned at a density of one every 200m along a linear feature. Trapping success varies seasonally, with the greatest chances of capture being during the mating season (January to April) or when juveniles are dispersing (September to November). For monitoring purposes trapping should be restricted to the mating season to remove the effects of short-term variability in productivity. There are various sex and age biases in terms of the ease with which individuals can be captured (Dunstone 1993).

Direct counts - The direct sighting and correct identification of American Mink are difficult within riverine habitats, but may be more readily applied in the few areas where the species occurs in coastal habitats.
**Indirect counts** - As with Otters, the presence of American Mink at a site may be determined from field signs, specifically faeces. With a small amount of training these can usually be separated from those of Otter, but separation from Polecat can be more difficult in certain circumstances. The consistency and colour of Mink scats depends on diet and on how fresh the scat is (Lawrence & Brown 1973). Hansen & Jacobsen (1999) have demonstrated that faeces of the three species can be readily separated using DNA analysis. Mink scats are usually deposited at conspicuous sites around dens, on prominent rocks, under bridges and on fallen tree trunks. There is some evidence from the literature that scat deposition varies seasonally with scats significantly more likely to be found during the summer and autumn (Wise *et al.* 1981). This is likely to be a result of changes in Mink activity and scat decay rates with season.

**Game Bags** - Game Bags are not likely to offer a reliable monitoring option for this species, since it is difficult to standardise information on recording effort (see Part III. A.2).

**Road-deaths** - As MMR note, road kills could provide incidental records of distribution, indicating where Mink had moved into new areas before other monitoring methods showed them to be present.

**Mammals on Nature Reserves** - Records of American Mink on nature reserves could be collated according to the suggestions outlined in Part III.B.6.

**Waterways Breeding Bird Survey (WBBS)** - American Mink, along with Otter and Water Vole, is one of the few species that could be monitored through the WBBS, although it should be stressed that this survey is currently still in its pilot stages and may not have funding for continuation beyond the end of the pilot period. Additionally, the survey is designed to survey a range of bird species associated with riparian habitats and is therefore not ideal for the transect monitoring of Mink field signs.

**22.4 POTENTIAL MONITORING SCHEMES**

Current monitoring of the Mink population takes place through the existing Otter and Water Vole surveys. Given the interactions between these three species it makes sense to continue recording Mink distribution as a component of these two schemes. This approach would provide a greater level of detail regarding the species interactions than would be possible were Mink to be surveyed in isolation.

Monitoring of American Mink populations should therefore remain a component of the schemes developed for Otter and Water Vole, either as a continuation of the existing monitoring methods or with the incorporation of a greater volunteer component. The Mammal Society has demonstrated that volunteers can be trained to identify Mink scats and that a sufficient network of observers can be generated for most of the UK. Professional recorders would be required for the more remote regions and technical support would be needed to help with data analysis and the identification of problem scats. Co-ordination of Mink monitoring would depend on decisions made about the co-ordination of Otter and Water Vole.
22.5 RECOMMENDATIONS

1) Monitoring of Mink distribution and abundance (through an index of abundance) should be undertaken as components of the proposed National Otter and Water Vole Schemes.

2) Populations on islands should be monitored as a separate scheme with the objective of determining distribution and likely threat to seabird colonies or other wildlife.

3) Ancillary data should be collected through the proposed Mammals on Roads (Part III.B.5) and Mammals on Nature Reserves (Part III.B.6) schemes.
23. BADGER *Meles meles*

A general increase in numbers has been witnessed this century, with particularly noticeable increases in some local areas during the last two decades.

23.1 RECENT AND ONGOING MONITORING WORK

**National Badger Survey (report based)** - The National Badger Survey was instituted in 1963, with the aim of establishing the distribution of Badgers in Britain. County Badger Recorders were asked to submit details of all setts known to them, together with information on sett size, position and soil characteristics. Records of over 4,300 setts were received including additional information from the Forestry Commission and the Biological Records Centre. These data were then used to establish the total likely number of setts per 10km square, allowing some interpretation and mapping of regional variations in sett density (Clements *et al.* 1988).

The data used in the National Badger Survey were accumulated over many years, meaning that some of the earlier records would have been out of date by the time the analysis was carried out. This may have been a particular problem in this instance because of the upsurge in illegal persecution by Badger diggers in the 1970s and the TB control measures being carried out by MAFF in the south-west. A further problem results from the fact that different surveyors may have been working to different standards, specifically with regard to the types of sett being recorded and to the level of effort put into gathering records.

**National Badger Survey 1985-1988 (fieldwork based)** - The first fieldwork based national survey of Badgers was carried out between the end of 1985 and the beginning of 1988, covering 2,455 1km squares. These squares were selected using a stratified approach with squares allocated within strata based on the 32 land classes of the ITE's Land Classification Scheme (Bunce *et al.* 1996). Within each square, fieldworkers followed standard methods recording Badger setts and signs of Badger activity. The results suggested that there were 42,891 (±3,851 (95% confidence limits) Badger social groups, with densities presented for each of the 32 ITE Land Classes (Cresswell *et al.* 1990). Additionally, the data were used to demonstrate regional variations in distribution (Cresswell *et al.* 1989).

It is worth noting that the data were reanalysed following changes to the ITE Land Classification, although this resulted in only a slight change to the estimate of the number of Badger social groups (Reason *et al.* 1993). Data from this survey were also used by MMR as part of an analysis to assess the power of this scheme to determine trends in different regions (MMR, p63-66).

**Badger Survey of Northern Ireland** - A similar approach to that used by Cresswell *et al.* (1990) was employed in Northern Ireland (Feore, Smal & Montgomery 1993), and in the Republic of Ireland (Smal 1995).

**National Badger Survey 1994-1997 (fieldwork based)** - Some 93% of the original 2,455 Badger survey squares covered between 1985 and 1988 were resurveyed as part of the second National Badger Survey (Wilson *et al.* 1997) allowing an estimate of change in the Badger population to be determined. This approach was adopted for two main reasons. Firstly, because Badger setts are not randomly distributed; ‘.. resurveying the same 1km squares, rather than surveying a new random sample of 1km squares, is best suited for detecting change in data where there are large 95% confidence limits about the population means.’ (Wilson *et al.* 1997). Secondly, repeatedly surveying the same squares allows the fate of individual setts to be
monitored and those factors leading to sett loss or gain to be quantified. In addition to the 2,271 squares resurveyed, a further 307 new squares were included, enlarging the sample database for future resurveys.

Changes to the Land Classification Scheme (Bunce et al. 1996) meant that the data were analysed according to seven land class groups. The results produced an estimate of 50,241 (±4,327 (95% confidence limits) social groups, an increase of 24% over the previous survey. Regional variations in both the number of social groups and levels of population change were also examined, as was the loss of individual setts.

23.2 MONITORING OBJECTIVES

Although the Badger population has been demonstrated to have increased within much of its existing range, there are substantial areas of seemingly suitable lowland Britain from which the species is absent. Even if the current degree of legal protection continues, it is likely that recolonisation of all suitable Badger habitat will take many decades. In view of this, and because of the susceptibility of Badgers to infection with Bovine TB (Cheeseman et al. 1981, 1989), persecution and habitat perturbations (Harris et al. 1992) it is important to continue regular monitoring of distribution and population size, the latter being based on the number of social groups. Such information should be considered as being of primary importance if changes in legislation are to be addressed in the future. Harris et al. (1992) outline the information required for Badger monitoring, namely:

(a) an estimate of the number of Badger setts in Britain;
(b) the distribution of setts per social group;
(c) the likely effects of land use change on Badger numbers;
(d) the potential effects of population perturbations on reproductive success;
(e) the effects of population density on group structure;
(f) the current rate of annual mortality.

In actual fact, much of this information has a modelling purpose, which could be considered additional to baseline monitoring. The baseline monitoring should consider changes in abundance and the number of social groups.

23.3 POTENTIAL MONITORING TECHNIQUES

Live-trapping - Badgers can be caught using cage traps baited with peanuts, in snares or with hand-held nets, the latter being used when Badgers are foraging within open areas at night (Cheeseman & Mallinson 1980; Harris 1982). Trapping is labour intensive and would not be practical at the national level unless used as part of a calibration exercise.

Direct Counts - Direct counts of individual Badgers can be made by watching active Badger setts (MMR). These should be watched either at dawn or dusk, unless night-vision equipment is available allowing watching to be undertaken throughout the night. MMR evaluated whether the accuracy of the number of animals counted improves with (a) the number of consecutive nights on which counting occurs and (b) with the number of observers (MMR: p112-116). It was found that accuracy increased with the number of nights counted, but that the use of multiple observers opened up the risk of double-counting the same individuals. It should also be noted that Badger activity is influenced by weather conditions (Cresswell & Harris 1988) and that emergence times may differ between habitats (Harris 1982).
Direct counts of Badgers could also be employed as a component of a Garden Mammal Watch approach (see Part III.B.7), with the presence/absence of Badger sightings in gardens (or maximum counts) being used as a basic index.

**Road-deaths** - Records of Badgers found dead on the road have been examined by several researchers (Killingley 1973; Jefferies 1975; Neal 1977; Davies *et al.* 1987). Although there are some differences between the conclusions of these studies, there appears to be a bimodal distribution to the seasonal pattern of Badger road deaths. In a study of 984 carcasses from southern England, Davies *et al.* (1987) found a similar seasonal pattern for both males and females, with peaks in February-April and July-August.

**Indirect counts** - Various field signs can potentially be used to monitor Badger populations including setts, latrines and tracks (Harris *et al.* 1989; Wilson *et al.* 1997). Badger setts are perhaps the most conspicuous of the field signs, and have been used as a measure of the number of social groups (Clements *et al.* 1988; Wilson *et al.* 1997). Since a Badger social group can have more than one sett within its range (active or inactive) it is important that different types of sett and their function can be distinguished. The following guidelines to classifying sett type have been established by Wilson *et al.* (1997):

- **main setts** - "these usually have a large number of holes with large spoil heaps, and the sett generally looks well-used."

- **annexe setts** - "these are often close to a main sett, usually less than 150 metres away, and are usually connected to the main sett by one or more obvious well-worn paths. They usually have several holes, but may not be in use all the time even if the main sett is very active."

- **subsidiary setts** - "these often have only a few holes. They are at least 50 metres from a main sett, and do not have an obvious path connecting with another sett. They are not continuously active."

- **outlying setts** - "these usually only have one or two holes, often with a little spoil outside the hole, have no obvious path connecting with another sett, and are only used sporadically."

The number of main setts in an area has been used to indicate the number of social groups. Attempts by MMR to relate the number of badgers using a sett to sett characteristics (see MMR: 112-116) suggest that it is not possible to use this approach to predict group size. However, other researchers state that there is a very strong relationship between group size and features of sett size and pattern of use (S. Harris, pers. comm.). A mean of 5.9 adult Badgers per social group was used by Cresswell *et al.* (1990) to approximate the size of the national Badger population. However, it was accepted that there is great variation in the number of Badgers making up a social group. Recent work has enabled the production of more precise estimates of social group size in different parts of the UK (Stephen Harris, pers. comm.).
Badgers regularly use a number of dung pits grouped at latrine sites. These have a territorial function (Kruuk 1978) and the number of latrines used by a group has been demonstrated to be related to group size. Even stronger associations can be detected where the number of individual dung pits or amount of faeces per kilometre of linear feature have been used (MMR, 115-116). However, Stephen Harris believes the MMR data to be flawed and that this technique only works in areas with high Badger densities. At low densities Badgers do not use latrines or dung-pits.

### 23.4 POTENTIAL MONITORING SCHEMES

Several monitoring options could be successfully applied to the Badger population and each of these is dealt within in turn.

**Periodic National Surveys** - The pre-existing grid of Badger survey squares, with the two national surveys already completed, forms an ideal basis for future monitoring of Badger populations. The approach detailed by Wilson *et al.* (1997) employs a suitable sampling protocol, including an element of stratification, which delivers the ability to monitor population change with the required degree of power. However, considerable professional effort went into covering some of the more remote strata (containing fewer Badgers) and it should be possible to use a more effective stratification to reduce the level of coverage in these areas while maintaining power. Consideration should be given to running simulations based on existing datasets to determine to what extent the existing stratification can be modified to achieve better sampling efficiency. It may prove possible to reduce the overall sample size and distribution of samples between strata. The other distinct advantage of continuing with the approach adopted in the most recent survey is that resurvey of the existing sites provides greater statistical power and continuity of historical information on changes to individual setts.

The volunteer involvement in this work increases the cost-effectiveness of the monitoring, allowing a large number of squares to be covered. Reducing the number of sites covered is unlikely to increase cost-effectiveness significantly, although it could reduce the number of volunteers requiring training and thus some of the associated costs.

Further consideration should be given to refining our understanding of the relationship between latrine/dungpit counts and social group size. This could increase the predictive power of using such counts to estimate population size rather than relying on estimates of the number of social groups. Wilson *et al.* (1997) note that changes to the Badger population can occur in two ways, either (a) a change in the number of social groups or (b) a change in the number of Badgers within social groups. There is '... a general perception that the number of social groups only increases slowly, particularly in areas of high population density.' Although such changes might be slow, they are likely to reflect a long-term increase in Badger population size. However, if it is possible to get an accurate estimate of the number of Badgers directly, through latrine/dungpit counts, then it could offer the opportunity to monitor shorter-term changes in group structure that may result from other factors (note the problems outlined above). Although this work may be at the cost of other monitoring options it does offer the potential to monitor any factors that may reduce the Badger population without a corresponding change in the number of social groups (e.g. some form of disease).

**Badger road deaths** - The Badger is one of the species considered for inclusion in the monitoring of animals seen crossing roads or found dead on roads, by recorders driving regular
routes (see Part III.B.5). This approach could generate a basic index providing ancillary information on a more regular basis than that produced by periodic (10-yearly) national surveys.

**Garden Mammal Watch** - The Badger is one of the species considered for inclusion in the monitoring of mammals recorded in gardens (see Part III.B.7). An index based on presence/absence or maximum counts (gathered on a weekly or monthly basis), could be established following the approach adopted for the BTO's Garden Bird Watch. This could also allow the extended monitoring of this component of the national population. There are few Badgers actually using urban areas, although a few more use gardens on the edges of villages and small towns. Badger use of gardens varies seasonally, often in relation to rainfall (Stephen Harris, pers. comm.).

**23.5 DEVELOPMENT AND VALIDATION STUDIES**

Simulations based on existing datasets should be used to determine to what extent the stratification used for the most recent Badger survey can be modified to achieve better sampling efficiency. It may prove possible to reduce the overall sample size and distribution of samples between strata while still maintaining the required power to detect a trend of 25% over 25 years.

**23.6 RECOMMENDATIONS**

1) The current format of the National Badger Survey should be maintained with the resurvey of existing sites every 10 years. The survey interval could be adjusted if required, this being an issue that should be examined by modelling data from the two surveys to establish how sample size and sampling interval can be adjusted to maximise survey efficiency and the power to detect the required levels of change.

2) Work examining the relationship between social group size and latrine characteristics should be continued to establish whether this approach offers increased predictive power. The flaw with this approach highlighted by Stephen Harris (pers. comm.), i.e. that there is no latrine production at low population densities, requires further discussion. This problem may not preclude the collation of valuable data on established populations.

3) Ancillary monitoring data should be gathered through schemes based on the Mammals on Roads scheme (Part III.B.5) and Garden Mammal Watch (Part III.B.7), and on records of Badgers within gardens. Harris (Harris 1984; Harris & Cresswell 1987) has demonstrated the different territoriality of urban badgers and monitoring of Badgers in gardens may make an important contribution to the overall monitoring of this species. This ancillary data would provide more regular information than that from a 10-yearly national survey.
24. **OTTER *Lutra lutra***

Widespread, but absent from much of central England and central belt of Scotland. Population recovering from historical decline, now showing expansion in range and numbers with consolidation most pronounced in areas with already established populations.

24.1 **RECENT AND ONGOING MONITORING WORK**

**National Otter Surveys - England** - Baseline survey work by the Vincent Wildlife Trust was carried out in England between 1977 and 1979, covering 2,940 full survey sites. These were distributed at approximately 5km intervals along each waterway, coast or lake/reservoir shore, within a grid of alternate 50km squares (north-west and south-east diagonals of each 100km square of the national grid. This gave a mean frequency of six sites per 10km square, with the sites themselves being 600m in length. Otter signs were found at 170 (5.78%) of these (Lenton *et al.* 1980). A second survey was undertaken between 1984 and 1986, rechecking the 2,940 original sites and an additional 248 sites (Strachan *et al.* 1990), during which Otter signs were found at 286 sites (8.97%). The most recent survey (1991-1994) examined the same 3,188 sites as in 1984-86, revealing Otters signs within 706 (22.15%) of them (Strachan & Jefferies 1996). A comparison of the results for those sites covered in all three surveys suggests a 304% increase in 14 years.

**National Otter Surveys - Scotland** - Survey work in Scotland has been carried out by the Vincent Wildlife Trust largely in parallel to that in England (1977-1979, 1984-1985, 1992-1994). The baseline survey work covered 4,636 sites (Green & Green 1980) with 57% of these sites being resurveyed during the second survey (Green & Green 1987). Sites surveyed during the second survey were those showing evidence of a suboptimal distribution from the baseline survey.

**National Otter Surveys - Wales** - Otter survey work in Wales again parallels that in England (1977-1978, 1984-1985, 1991) with baseline work suggesting that 20% of survey sites were occupied (Crawford *et al.*, 1979). Repeat survey work was carried out in 1984-1985 (Andrews & Crawford 1986) and 1991 (Andrews *et al.*, 1993) with the proportion of ‘positive’ sites rising to 38% and 53% respectively.

**National Otter Surveys - Northern Ireland** - Northern Ireland was surveyed as part of an all-Ireland sample survey between 1980-1981 (Chapman & Chapman 1982). Of the 2,177 sites covered across the whole of Ireland, Otter signs were found at 92%.

All these national surveys employed a similar methodology: ‘full survey sites' were examined by a surveyor who walked one bank of a watercourse for up to 600m searching for Otter spraints. During the earliest surveys once a spraint was found the search was terminated. During successive surveys sites were revisited at approximately the same time of year to reduce potential seasonal bias.

**National Water Vole Surveys** - The presence of Otter signs was recorded as part of the survey work carried out during the two national Water Vole surveys (Strachan & Jefferies 1993). During the most recent Water Vole survey an attempt was made to determine whether Otter
distribution could be adequately monitored using the Water Vole grid. This demonstrated that, although there were some similarities within the core Otter range, in most cases the differences were marked suggesting that the Water Vole sampling design was unsatisfactory for Otters (Don Jefferies, pers. comm.). There is very little overlap between those sites selected for the Water Vole survey and those selected for the Otter survey. This is largely a result of the different habitat requirements of the two species.

Environment Agency - The Environment Agency's 'River Habitat Survey' documents the presence of Otters in conjunction with the collation of data on habitat and river features. Additional training may be needed to ensure that RHS recorders can identify Otter spraints. In addition to this, the Environment Agency is currently funding another Otter survey of England, to be based on the existing grid of squares used during the VWT surveys. Fieldwork will be carried out by the Environment Agency's own Otter Officers (based regionally) with sites revisited at a similar time of year to that used in the previous studies.

Wildlife Trusts - A large number of projects examining the distribution and status of Otters have been established nation-wide. These employ a range of different methods, reflecting their different objectives, and are outlined in The Mammal Society's Current Projects.

24.2 MONITORING OBJECTIVES

A number of the objectives laid out in the JNCCs 'Framework for Otter Conservation in the UK 1995-2000' require the input of data acquired through monitoring. This requirement for monitoring data is identified within the following action plan aims:

5.5.4. to develop and implement methods to estimate Otter numbers and permit population modelling.

5.5.5. to monitor populations and distribution of Otters throughout the UK, including local survey to monitor the expansion of fringe populations.

5.5.6. to pass information gathered during survey and monitoring of this species to JNCC in order that it can be incorporated in a national database and contribute to the maintenance of an up-to-date Red List.

Taken together, these aims suggest that monitoring should be targeted towards (a) those populations on the edge of the current range of expansion and (b) those areas where population consolidation is being prevented by pollutant levels within specific catchments (Mason & Macdonald 1992). Additionally, the interactions between Otters and Mink suggests that attention should be given to areas where these two species occur together. Continuation of the periodic national surveys would provide information of value for (a), and to a lesser extent (b), but more detailed locally based work would be needed to examine the interactions between Otters, pollution and Mink.

24.3 POTENTIAL MONITORING TECHNIQUES

Live-trapping - Otters can be trapped in box traps (Kruuk 1995; Durbin 1998) baited with fresh spraints (MMR) placed near well-used sites. However, this method is time-consuming and not readily applied to a species living at low densities.
**Direct Counts** - MMR note that direct sightings may give a more accurate estimate of abundance than sign surveys on some islands, presumably stemming from the work of Kruuk et al. (1989).

**Indirect Counts** - The presence of Otters at a site may be determined from various field signs including sprainting sites, holts, tracks, runways and individual spraints themselves. Of these, spraints provide the best indication of Otter status within a given area (Jenkins & Burrows 1980; Mason & Macdonald 1987), having a territorial function. Otter spraints are characteristic and can be readily separated from Mink scats by observers with only a small amount of training (Gillie Sargent, pers. comm.). Additionally, it has been demonstrated that Otter faeces can be distinguished from those of Polecat and Mink through the use of DNA analysis (Hansen & Jacobsen 1999). Bas et al. (1984) found that most spraints were located in places that were densely wooded or well-wooded, with spraints deposited on boulders, under trees, on tree trunks and tussocks. However, sprainting behaviour appears to differ between habitat types and the implications of this for spraint decay rates should be considered (Jenkins & Burrows 1980; Kruuk et al. 1986; Kruuk & Conroy 1987; Mason & Macdonald 1987). The distribution of spraints appears to reflect centres of activity and points of contact with other Otters (Green et al. 1984).

Otter spraints appear to offer an ideal means by which the presence of Otters at a site can be established. The number of spraints (or spraint density) can be used to determine Otter abundance (or activity), although this approach may be less suitable in coastal habitats. Kruuk et al. (1986), working on Shetland, could find no correlation between sprainting and the frequency of use of an area by Otters and concluded that their findings cast '...doubt on the use of spraint surveys as a method to assess habitat utilisation by Otters'. However, coastal Otters may show different sprainting behaviour to riverine populations. Mason & Macdonald (1987) note that the demonstrated seasonal cycle in sprainting activity (Erlinge 1968; Mason & Macdonald 1986) may '...invalidate any proposed relationship between spraint numbers and Otter populations.' Importantly, these authors go on to assert that '...the level of variation in sprainting at sites between catchments can be such that, providing the sample size is sufficient, the technique can be used broadly to define the status of an Otter population.' Therefore, with large enough sample sizes, spraint density may provide a broad indication of population status and, as Mason & Macdonald (1987) note, '...such data may become more valuable when part of a monitoring programme, rather than a single survey.' These sentiments are echoed by Jefferies (1986) who later demonstrated correlations between spraint density and percentage occupancy of survey sites for the most recent Otter survey in England (Strachan & Jefferies 1996).

Kruuk et al. (1989) found that in coastal habitats there is a relationship between the number of holts and the number of Otters (see MMR for elaboration).

**Game Bags** - Hunting records from packs of otter hounds have been used to illustrate the historical decline of the Otter (Chanin & Jefferies 1978). However, the legal protection currently afforded to the Otter and the cessation of hunting by this method prevent the possibility of using bag records as a monitoring tool.

**Road-deaths** - Records of Otters killed on roads can provide some information on distribution (see objective 5.5.5. in Framework for Otter Conservation on the UK 1995-2000) and on various aspects of physiology and toxicology (Kruuk et al. 1997). Although this approach is not likely to provide information of the type required for monitoring purposes, it could be used to pick up records of Otters as they move into new areas, before the population establishes itself at a level where it could be detected through other monitoring methods.
**Mammals on Nature Reserves** - Records of Otters on nature reserves could be collated according to the suggestions outlined in Part III.B.6.

**Waterways Breeding Bird Survey (WBBS)** - Otter, along with Mink and Water Vole is one of the few species that could be monitored through the WBBS, although it should be stressed that this survey is currently still in its pilot stages and may not have funding for continuation beyond the end of the pilot period. Additionally, the survey is designed to survey a range of bird species associated with riparian habitats and is therefore not ideal for the transect monitoring of Otter field signs.

### 24.4 POTENTIAL MONITORING SCHEMES

Clearly, there are a number of options available which can be used to achieve the monitoring objectives. Given that a grid of survey sites is well-established and that three national surveys have been undertaken (with a fourth about to begin - Environment Agency), it would seem unwise to dismantle what is already an adequate monitoring system without good reason. The historical data available from the VWT sites provides information on population change as well as suggesting likely reasons for that change. The detailed information on Otter/Mink interactions that has come from revisiting the same VWT sites in each survey could not have been achieved had different sites been selected randomly each time. Continuity is important, not only for this reason, but also because it allows small changes in the Otter population to be monitored more effectively by reducing the variation associated with selecting a new sample of squares each time a survey is carried out (see Part II).

Therefore, a different monitoring scheme should only be used if the current scheme fails to provide sufficient data for monitoring or if it were not economically feasible to continue funding such a large multi-annual programme. The current scheme delivers information identifying trends in the Otter population with acceptable levels of precision, demonstrating the change in range and highlighting those areas where the population is not consolidating as effectively as elsewhere. It therefore satisfies the primary objective, although it is expensive to fund. Consequently, a replacement scheme could be argued for on economic grounds if it were able to deliver adequate monitoring data at a greatly reduced cost. This would also have to be offset against the loss of an already existing long-term dataset. It should also be noted that the low density of the Otter population in some areas would require sampling as intensive as that employed for the VWT surveys, potentially suggesting that a more economical approach may compromise data quality.

The replacement suggested by MMR has the potential to provide more detail than the current scheme, but this additional material is likely to be surplus to the basic requirements of a monitoring scheme for Otters in that a smaller sample size could be used without reducing the ability to detect trends of the required magnitude. Additionally, combining the Otter work with that for Mink and Water Vole (as suggested by MMR) may reduce survey efficiency, as fieldworkers require different 'search-images' for the different species. A combined survey might also fail to target fieldwork effort most effectively, notably because the three species often occupy different riparian habitats. The most recent Water Vole survey highlights this, with the grid of Water Vole survey sites providing a poor estimate of Otter population size (see above). This is the result of an inappropriate selection of study sites (for Otters) and sampling intensity (Don Jefferies, pers. comm.).

A volunteer-based transect method involving the recording of field signs (across the grid of existing sites) could provide a more cost-effective monitoring programme, while maintaining
continuity of the historical dataset. The Mammal Society has demonstrated that volunteers can be trained to identify Otter spraints and, with technical support to help identify difficult spraints, there is no reason to expect any reduction in data quality with volunteer involvement. Use of multiple fieldworkers, rather than the single fieldworker employed on the VWT, has distinct advantages (see Part V), although the seasonal component of the existing methodology may need to be changed. It also appears that a sufficient number of volunteers could be recruited (Stephen Harris, pers. comm.). The use of trained volunteers could be tested during a pilot study or as a component of the forthcoming Otter survey of England. Professional recorders would be needed in the more remote parts of the country where observer coverage would otherwise be low.

Although trained volunteers fieldworkers could carry out much of the survey work, they would need to be supported by a professional national co-ordinator (also co-ordinating American Mink and Water Vole) and possibly local co-ordinators (such as the Environment Agency Otter Officers). A proportion of collected spraints could be sent in for validation and a proportion of the survey sites could be visited by professionals, again for validation purposes.

24.5 DEVELOPMENT AND VALIDATION STUDIES

A data-modelling exercise (using data from the national Otter surveys for England) should be used to establish whether the number of sample sites can be reduced without reducing the power of the approach for detecting trends of say 25% over 25 years. This exercise could also be used to examine the ideal interval between surveys based on the power of detection and the costs of implementing the survey. This could be carried out at the same time as modelling potential sampling protocols for other species (e.g. Badger: Cresswell et al. 1990; Wilson et al. 1997).

24.6 RECOMMENDATIONS

1) Monitoring work should build on the three previous national Otter surveys and there is a great deal to be gained by continuing a national Otter survey every seven years using volunteer input. The recommended interval of seven years is based on the balance between survey costs and the need to obtain regular monitoring data. The steady change in the Otter population is not so dramatic that more regular surveys are currently needed, although the sampling interval could be adjusted in light of the modelling exercise recommended in (4) or as a result of changes in the rate of Otter population change.

2) More intensive monitoring should be carried out at a reduced number of sites to provide a better understanding of the processes limiting recovery in certain areas. Such work should examine the relationship between population recovery and catchment characteristics (notably pollution) thus enabling aim 5.5.4 of the action plan to be addressed. Liaison with groups carrying out ongoing work at the local level may highlight appropriate study areas.
3) Work examining the feasibility of monitoring Otter populations using the VWT methodology and sites but with volunteers, rather than a single professional observer, should be investigated. The completion of this pilot work, together with that outlined in (4) should be completed prior to the implementation of recommendation (1).

4) A parallel monitoring approach would need to be developed for coastal populations, which, although seemingly more stable, are at risk from catastrophic events such as oil spills and the effects of sea-level rise.

5) Data from the previous Otter surveys should be used to establish whether the number of sample sites can be reduced without reducing the power of the approach for detecting trends of 25% over 25 years. The value of altering the survey interval should also be evaluated as part of this modelling process.

6) More effort should be targeted towards understanding and quantifying the relationship between Otter density and spraint density. As Otter numbers increase and the number of occupied sites also increases, so data on the occupancy of sites becomes less valuable for monitoring purposes. Abundance data will highlight where changes in numbers occur without a corresponding change in the number of occupied sites. This could be important.

7) Ancillary data should be gathered through Mammals on Nature Reserves (Part III.B.6) and Mammals on Roads data (Part III.B.5) both of which would contribute to the gathering of distribution data, with the former also providing a simple index of occurrence on an annual basis.
25. WILDCAT *Felis silvestris*

Native; rare and restricted to upland Scotland (extinct in Ireland, England and Wales); population probably stable but threatened by hybridisation with Feral Cats *F. catus*: genetic status in question.

25.1 RECENT AND ONGOING MONITORING

**Game Conservancy Trust National Game Bag Census** - Game Bag data were collected centrally by the GCT from 1960 until 1985, when the Wildcat was given legal protection. The data will suffer from the problems inherent in all Game Bag records (see Part III.A.2). More Game Bag data will not become available in the future because Wildcats are hugely unlikely again to be made legal quarry (although persecution certainly persists).

**Wildcat Survey of Scotland** - A questionnaire survey (1983-1987) involving interviews with gamekeepers, forest rangers, volunteers and others which solicited sightings information and was widely publicised in Scotland (Easterbee *et al.* 1991). Sampling was based on the 100x100km national grid squares, with several 10x10km squares sampled within each 100x100km square. Wildcats in blocks of 3x3 10x10km squares were then classified as rare/absent, rare, occasionally seen or established.

**SNH survey of wild-living cats in Scotland** - As part of a study investigating the definition of the Wildcat and the phenotypic variation found in the extant population of wild-living cats, Balharry & Daniels (1998) supervised trapping efforts across Scotland using baited cage traps (primarily for the purpose of collecting blood samples and morphological data). Formal attempts to estimate abundance or other population parameters were not made, but a total of 44 cats were caught over 5,558 trap-nights of effort (giving a mean of c. 130 trap-nights per cat). Comparable numbers of non-target species were also caught, most of which were Pine Martens.

**Investigation of Wildcat genetics** - Studies of the genetics of Wildcats, Feral Cats and their hybrids by SNH and the Wildlife Conservation Research Unit (University of Oxford) are currently in progress.

25.2 WILDCAT GENETICS

Wildcat morphology has traditionally been defined as being identifiable from that of Domestic and Feral Cats by means of a number of field characters. The typical coat is a tabby mixture of black and a grey-brown which varies in darkness. Key diagnostic features are large size, long legs, no dark stripe on the back at the base of the tail, fewer dark stripes on the body and fewer rings on the bushy, black-tipped tail (Kitchener 1995). Introgressive hybrids with Feral Cats are identifiable by various “domestic” features such as smaller size and unusual coat colours such as patches of white: colour variants in Wildcats are believed to be very rare (Kitchener 1995), although this could surely reflect a reporting bias against “hybrids”.

Recent morphological analyses have suggested that there is no “genetically pure” population of Wildcats, derived from the native, ancestral stock, which can be distinguished from Feral Cats (Balharry & Daniels 1998). This suggests that introgression has proceeded to such an extent that the feral and wild populations are now effectively integrated, and that the (single) type specimen from which Wildcat morphology was defined (in 1907) may have come from a population which already possessed feral genes. Balharry & Daniels (1998) found that two groups of cats (“group 1” and “group 2”) could be identified by a linear discriminant function incorporating gut length
and skull size. Other features, such as pelage colour and pattern and other morphological measurements did not allow any other groupings to be defined. Group 1 cats had larger skulls and shorter guts, as well as a higher ratio of tabby to other coat colours (but coat colours were far from exclusive). Records of group 1 cats also tended to be separated geographically from those of group 2 cats and tended to come from colder, drier areas. It is tempting to suggest that group 1 cats represent genuine Wildcats, but there is no evidence to support this conclusion. In particular, the possibility that the morphological differences between group 1 and group 2 cats in fact reflects the influence of natural selection on the same (wild mixed with feral) gene pool cannot be discounted.

Balharry & Daniels’ (1998) analyses have been criticised (A.C. Kitchener, pers. comm.), but no written account of the relevant arguments was available at the time of writing. It is possible, for example, that Balharry & Daniels’ analyses involved only hybrid individuals and that a true Wildcat population exists in areas that they were unable to sample. It would seem that the only way to resolve the discrepancy would be to investigate the genetic differences between the traditional Wildcat phenotype and those of Feral Cats and putative hybrids. The genetic investigations currently in progress should hopefully provide the necessary information.

25.3 MONITORING OBJECTIVES

Considerable confusion remains as to how a “Wildcat” should be defined. At present, opinion is divided on whether a genetically distinct and identifiable Wildcat, as opposed to a gradation from more wild to more feral genotypes, exists (Kitchener 1995, pers. comm.; Balharry & Daniels 1998). Identification of the characteristics of the population to be monitored is the first priority and must precede the establishment of any monitoring scheme.

It may not be necessary to identify a genetically and/or morphologically distinct Wildcat population to design an effective monitoring scheme. We suggest that monitoring should focus on cats in the niche of the ancestral Wildcat (insofar as it exists in contemporary Britain). If a distinct Wildcat population does exist, this will form some of the population monitored (along with hybrids which possess “wild” genes). If Scottish wild-living cats are a fully hybridised population, it suggests that Feral Cats and Wildcats cannot be regarded as different species in any biologically meaningful sense. It may be notable that domestication has selected cats primarily for exotic pelage colours and socialisation. If these form the principal differences between the wild and domestic genotypes, the distinction is likely to disappear rapidly from feral populations by natural selection: populations in the “Wildcat niche” should therefore become “wilder” over time (given that introgression is limited in the future). In addition, if the aim of the conservation effort is to preserve genes from the ancestral Wildcat population, these may now be found in many “hybrid” and “feral” individuals: trying to conserve (and monitor) any given phenotype would then merely be an exercise in aesthetics.

We suggest that the aims of monitoring could be (i) to monitor long-term changes in the genetic and morphological make-up of the wild-living cat population in Scotland (concentrating on areas away from human habitation), and (ii) to monitor the range and abundance of wild-living cats in general. Areas considered as core ones for the Wildcat phenotype (with buffer zones around them) could be chosen as key areas for the monitoring of population trends and introgression by feral stock.
25.4 POTENTIAL MONITORING TECHNIQUES

**Spotlighting** - This method would allow visual transects to be conducted (at night), potentially giving standardised information. However, the method has important disadvantages (see Red Fox species account: IV.16). Identification is also likely to be a problem if phenotypic distinctions are to be made among wild-living cat types.

**Road-deaths and other carcasses** - Carcasses provide a cheap source of detailed information on morphology and (potentially) genetics which can be stored for reassessment in the light of future developments in Wildcat taxonomy or in policy. Specific solicitation of Wildcat carcasses is likely to be necessary since encounter rates will be very low and the species is unlikely to be monitored effectively by a generic Mammals on Roads survey (see Part III.B.3). Carcasses will be obtained more frequently from areas near towns and villages, so such biases would have to be taken into account.

**Live trapping** - This method is probably the only one that would allow unbiased sampling of all habitats and also allow morphological recording and genetic sampling, but it has important disadvantages. It requires very specialised training, licensing and considerable field effort. Landowner permission and free access may also be a problem, especially where cats are most abundant, because illegal control is most likely to occur on such land.

**Questionnaire surveys** - Both the general public and experienced professionals such as reserve wardens, gamekeepers and foresters could be targeted to supply sightings information with as much ancillary information as possible. Such an approach would provide information on changes in range and perhaps, crudely, on abundance, but would be highly dependent on the precise questions asked. A useful approach might be to ask not just for records of Wildcats, but of Feral Cats too, together with some record of the reason for the decision made (e.g. pelage colour, behaviour). As with most protected species which are considered a threat to gamekeeping interests, records (or a lack of records) from shooting estates would have to be treated with caution.

**Field signs** - Cat scats are deposited in exposed sites as territory markers, so could be used to assess presence or abundance. The scarcity and distribution of wild-living cats in Scotland means that sufficient numbers of cat scats are unlikely to be recorded by a generic Sign Transect Survey (see Part III.B.2) to monitor the population which is of conservation interest. Given suitable genetic markers, scats could also be used to monitor the genotypes of wild-living cats. As with carcasses, a central collection of scats would allow re-assessment of any classification in the future.

25.5 POTENTIAL MONITORING SCHEMES

**Road-deaths and live-trapping** - MMR recommend that Wildcats are counted by spotlighting and faecal counts in surveys also monitoring Red Foxes (which would be conducted every seven years), combined with the collection of road-deaths which could be stored until genetic differentiations can be made. They concede that spotlighting for Wildcats has yet to be tested: given the problems with counts of foxes by spotlight (see Red Fox), it is unlikely that Wildcats (a still more wary species) will be counted easily, although they are shot by spotlight. Cats and foxes can also be difficult to distinguish at the edge of spotlight teams (S. Harris, pers. comm.). MMR also suggest that standardised live-trapping may present the most reliable monitoring technique, despite the effort and cost involved. However, live-trapping could well be biased by problems with access, so may not justify its high cost.
Combined Mammals on Roads, questionnaire and field sign surveys - We suggest that an ongoing scheme soliciting road-deaths and questionnaire data would be the best core approach, in accordance with the consensus of expert opinion in MMR (p. 180). Mammals on Nature Reserves (Part III.B.6) could also contribute. Collation (including report/newsletter production) could be via SNH or a central mammal monitoring body and would perhaps be annual for questionnaire data and five-yearly for road-deaths (whereupon the accumulated collection of corpses would be measured and DNA samples analysed). The collation ought to require no more than one month of staff time per year. Occasional scat surveys would then allow estimates of cat abundance and distribution to be made and these could be calibrated genetically via the road-deaths data. Such surveys would probably have to be conducted professionally because of the likely difficulty in volunteer recruitment in remote areas. Access problems could perhaps be reduced by the broadening of such a survey to include other, less contentious species, making the survey less sensitive politically, even if the additional data accumulated were of little value for the extra species.

25.6 RECOMMENDATIONS

1) Consensus on the characteristics of the wild-living cat population to be monitored must first be reached.

2) We suggest that the population to be monitored should consist of all wild-living cats found away from centres of human population. Road-deaths and questionnaire data could be used to monitor this population, with records categorised as wild or feral according to all available criteria (i.e. appearance, behaviour, measurements, etc.). Where possible, genetic reference material should be collected, stored and analysed periodically (provided that suitable genetic markers can be found) to monitor any spread of hybrids or Feral Cats. Such surveys would give information on changes in range and distribution.

3) Occasional scat surveys should also be considered. They would supply information on changes in the abundance of wild-living cats which could be calibrated by phenotype (and perhaps genotype), if desired, by the results of the monitoring suggested under point 2. Given suitable genetic markers, scat collection could perhaps also contribute to any genetic calibration.

4) The Mammals on Roads and Mammals on Nature Reserves schemes could contribute useful data to the monitoring of wild-living cats.
26. WILD SWINE *Sus scrofa*

Native but hunted to extinction. Current population of 100-200 in c. 100km² of Kent and East Sussex originated from only two escapes, that of 20 or more in a smaller area of Dorset from just one escape. Widely kept in captivity and escapes not uncommon.

26.1 RECENT AND ONGOING MONITORING WORK

None but CSL (1998) has assessed the species’ current status in England and CSL is currently studying the British population.

26.2 MONITORING OBJECTIVES

We note that Howells & Edwards-Jones (1997) concluded, on the basis of a simulation model of the Minimum Viable Population, that “the goal of establishing a self-sustaining population of Wild Boar in Scotland is unrealistic in the short-term”. We also note that, in contrast, Feral Pig and Wild Swine populations have become established in very many parts of the world, often on quite small islands (Lever 1994) and that the two English Wild Swine populations seem to have established themselves readily. Given this practical experience, the analysis by Howells & Edwards-Jones should not be taken as an excuse for complacency in respect of Wild Swine.

It should be noted that there are strong views on the presence of Wild Swine in the British countryside. For example, Jackson (1999) argues that it is already far too late to eradicate the species and that it should be managed properly as a quarry species, whereas the Game Conservancy Trust argue that it can and should be eliminated (Dr Stephen Tapper, pers. comm.) Some welcome its return as a native animal, playing its natural part in British forests and providing an economic resource through hunting. Others point out that the ecology of Britain is now quite different from what it was before Wild Swine became extinct (in particular, predators such as Brown Bear *Ursus arctos* are no longer present and various other herbivores have been introduced); they point to potential problems of both economic conservation damage to woodlands, damage to crops and agriculture, predation on lambs, attacks on people and dogs, road traffic accidents, and the dangers (in the crowded British countryside) of using appropriately high-powered fire-arms to hunt Wild Boar. Given the potential economic impact of this species and the strength of the divergent views of how it should be managed, sound monitoring is particularly important.

26.3 RECOMMENDATIONS

We recommend that the monitoring of this species be considered promptly when CSL has reported on its current project. It will then be possible to define more clearly the nature of the problem (if there is one), the management objectives and the best monitoring methods for use in Britain.
27. DEER

As recognised by MMR (p. 38), deer are a special case among the groups of mammals found in the UK. They are of interest to people concerned with conservation, forestry, agriculture, animal welfare and field sports: these interest groups have each collected data on some aspects of deer populations, but in ways both diverse and often less than ideal for monitoring (especially at the national level). A detailed assessment of current and historical deer monitoring is given by MMR, so we do not repeat it here. Instead, we focus on how new proposals can be combined with the high quality data which is already being collected, to allow deer populations to be monitored nationally. Following MMR, we deal with the monitoring of all UK deer species together: although they exist in a wide range of habitats and vary in behaviour, discussion of the pros and cons of monitoring approaches applies to all species. MMR were asked to consider only four deer species; we have broadened the species range to consider all species living wild in the UK.

RED DEER *Cervus elaphus*: native to Britain and Ireland; locally very abundant, but distribution patchy, rarer in Ireland and absent from the North; numbers stable either naturally or under control by culling; also subject to translocations and introductions.

SIKA DEER *C. nippon*: introduced to Britain and Ireland; widespread in Scotland, more localised in England, Wales and Ireland; not abundant, but increasing in Scotland. Hybridising with *C. elaphus* and may effectively be indistinguishable.

FALLOW DEER *Dama dama*: introduced to Britain and Ireland; widespread, especially in southern Britain and central Ireland, but patchily distributed elsewhere.

ROE DEER *Capreolus capreolus*: native with reintroductions in Britain, absent from Ireland; widespread throughout Britain except Wales and Midlands, abundance patchy; range is expanding, probably along with abundance.

REEVES’ MUNTJAC *Muntiacus reevesi*: introduced; south and east Britain only, patchy distribution reflects introduction sites; rapidly increasing but may soon saturate some areas.

CHINESE WATER DEER *Hydropotes inermis*: introduced; uncommon, localised, primarily found near introduction sites in south-east England; not increasing significantly.

27.1 RECENT AND ONGOING MONITORING WORK (REVIEWED IN DETAIL BY MMR)

Historically, deer monitoring has been organised mostly only at a local scale, with a view to the management of local populations either for sporting interests or to control damage to agriculture and forestry. The best ongoing schemes monitoring abundance are as follows:

The Deer Commission for Scotland (DCS)/Scottish Deer Management Groups - annual and five-yearly total counts for Red and Sika Deer populations made when the animals are relatively concentrated on lower ground in late winter and therefore most easily counted. Complete censuses of Scottish populations are made. There is some doubt as to the genetic integrity of many Scottish Red Deer populations after possible hybridisation with introduced Sika Deer, but this may simply mean that effective monitoring cannot distinguish between the two “species” and their hybrids.

Services Branch of the British Deer Society - complete annual censuses of all deer found on Ministry of Defence land (all those listed except Chinese Water Deer) are made using the most appropriate method for each site: where complete, direct counts are not possible, population estimates are made using correction factors for unseen individuals.
**Forestry Commission** - the monitoring of all deer species on all Forestry Commission properties using locally appropriate methods is now being encouraged, and will be made more rigorous and standardised in future, with pellet counts and distance sampling by thermal imaging as the core approaches. Population indices, rather than complete censuses, are likely to be the goal of this monitoring.

**Exmoor Deer Management Society** - annual census data for deer on Exmoor.

The precise methods used by these surveys differ, but all aim to provide estimates of population size within designated areas. In each case, the surveying organisations have a vested (and often commercial) interest in promoting the accuracy and precision of deer monitoring which should only enhance the value of these surveys. Potential biases due to political pressures must, however, always be considered when information on politically sensitive issues is collated.

Other data collected under various schemes primarily comprise **cull data, bag returns and presence/absence surveys** (conducted nationally by the British Deer Society). The latter would clearly give information on changes in distribution, but may not be closely related to changes in abundance, especially in terms of relationships with habitat (Chamberlain et al. 1999). Relationships will also be weaker for species which live in large social groups, as do Red, Sika and Fallow Deer. As with all population sampling methods, the utility of cull data, bag returns and other mortality data, such as those from road accidents for monitoring abundance, depends on the recording of “sampling effort”. Unless effort has been constant, the effects of changes in methods must be controlled for in indices of changes in population size. In cull and bag data, the time spent stalking, the quality of equipment, the ability of personnel, the methods used and the areas visited must all be recorded, together with information on the effects of variation in these parameters (see Part III.A.2). Changes in any of these could produce spurious apparent changes in a population index. Nevertheless, mortality data (if complete) can be used to assess population size and structure retrospectively and thus to check previous censuses (MMR). Such information can be vital for the management of local populations, because of the importance of population structure in the design of culling strategies.

### 27.2 MONITORING OBJECTIVES

Nationally, it may be desirable to monitor changes in range and abundance for each species to provide information on conservation status and biodiversity. Local monitoring may also be extremely important for deer because it is at the local scale that any management which aims to prevent habitat damage or to estimate the size of sustainable annual harvests must occur. Monitoring of range change may be important for the species which are believed to be expanding their ranges: Sika, Roe and Reeves’ Muntjac. Deer are important economically and can have large impacts on their environments and on other wildlife: these factors suggest monitoring priorities in addition to those due to the monitoring of the health of the countryside.

### 27.3 POTENTIAL MONITORING TECHNIQUES

A comprehensive review of the methods available for the monitoring of deer is presented in Mayle & Staines (1998) (summarised in MMR), so we consider only the best of the methods here. The diversity of habitats occupied by deer mean that a single monitoring approach could not be recommended for all species, or indeed across the complete range of some individual species. Mayle & Staines recommend a different basic method for each of open hill and wooded habitats and also consider the use of more technologically sophisticated approaches.
Open hill areas (Red and Sika Deer): direct counts - Direct count methods as currently applied by the Deer Commission for Scotland are recommended by Mayle & Staines (1998). Counts might be made more often than is currently the case, but otherwise the approach used by the DCS could be adhered to. In Scotland, counts are made by teams of stalkers who use radio contact to avoid double-counting in each of 50 blocks which cover the whole range of red deer, and which each feature “fairly self-contained” deer populations. Animals are counted on open ground and, where necessary, flushed from cover. Some will nevertheless be missed, so the counts are regarded as minima. The counting system is designed to estimate total population size but might provide reliable information on population changes more efficiently if a randomised sample of blocks were covered using repeat visits. The nature and spatial distribution of counter effort within open hill areas outside Scotland would determine whether a sampling or total count approach would be most appropriate in each area.

Woodland and partially wooded landscapes: pellet-group counts - Mayle & Staines (1998) concluded that total and sample (plot or transect) counts are unreliable because deer are cryptic in these habitats and therefore difficult to detect. Of indirect methods, Mayle & Staines concluded that faecal pellet counts were the most suitable, made using one of two methods: faecal accumulation rate (FAR) or faecal standing crop (FSC), both of which are best conducted in winter when vegetation growth is low and decay times are long. FAR requires multiple visits to a sample plot or transect strip and involves the recording of the pellet groups present on each occasion. FSC requires only a single visit but depends critically on decay rates. Defecation rates and decay times vary with habitat, diet and season and need to be known if absolute abundance is to be estimated. However, the estimation of population change would require only that these parameters do not change over time within plots. Mayle & Staines (1998) suggest that FAR is best used where deer densities are high and FSC where densities are lower, but that FSC may also be the best option when observer time is limiting since fewer, less time-consuming visits to each plot are required. Pellet groups suffer from a potential identification problem where species of a similar size co-exist and/or where sheep and goats are also found. In such cases, data where species cannot be determined with certainty can be omitted from population indexing analyses: although this would bias estimates of absolute abundance, it should not affect relative indices unless identifiability changes with time. The identifiability problem may mean, however, that it is not feasible to use volunteers for pellet count surveys where more than one similarly-sized deer species occurs. Some experts consider that identifiability presents insurmountable problems that invalidate pellet-based methods (in practice) for deer monitoring (S. Harris, pers. comm.).

Other methods - Mayle & Staines (1998) discuss a range of further monitoring approaches. In terms of providing improvements on estimates produced using the methods described above, the most important of these are aerial transect counts for deer in open country (using helicopters or microlight aircraft) and transect counts with distance sampling done using thermal imaging. Both of these approaches will probably be too expensive to be practical for repeated, large-scale monitoring projects, but could perhaps be used for the purposes of calibration, either in a one-off national survey or in the repeated (annual) censusing of particular populations.

Visual transects - The line transect methods as used by the Breeding Bird Survey (see Part III.A.1) are not ideally suited to deer monitoring (Mayle & Staines 1998, MMR) but this survey
produces presence/absence information at the 1km square scale together with standardised
habitat data which could be useful. The chief advantage of BBS data in this context is that it is
already being collected and is based on a random sample of the UK landscape. The BBS could
also provide a useful independent check on presence/absence data collected by the British Deer
Society and the Institute of Terrestrial Ecology (see MMR Chapter 2, Section 3). Sightings data
from Winter Transects (see Part III.B.1) may supply better data on deer because the animals will
be more visible.

Specific, deer-focused transect counts form a monitoring technique recommended by some
experts (S. Harris, pers. comm.): to be most effective, these counts would be conducted at first
light or at dusk and would follow routes along the edges of woods and along rides. Easily
identified field signs (such as tracks) could also be recorded at the same time.

**Presence/counts in gardens** - The occurrence of deer in gardens could provide important
information, especially on range changes, for Reeves’ Muntjac and Roe Deer, which commonly
enter gardens where they occur.

**Road-deaths** - Road-death sightings, especially when combined with measures of sampling
effort as recommended for our proposed Mammals on Roads survey (see Part III.B.3) could
supply useful information, especially on distribution and changes in range. Again, the smaller
species will be monitored best by such data.

**Presence/counts from nature reserves** - Reserve wardens could contribute valuable data,
especially on presence/absence, which could be used to chart changes in range. Reserves are
unlikely to be representative of wider land-use, so will be of less value as a source of count data
(but see Part III.B.4).

### 27.4 POTENTIAL MONITORING SCHEMES

**MMR recommended approach** - As part of the QQ grid-based MaMoNet system, MMR
recommend transect-based pellet-group or direct counts (with supplementary methods including
vantage point counts, woodland edge counts and analyses of cull data as necessary or appropriate
for particular species) for five randomly selected 1km squares within each 10km square to be
surveyed (although the details of the method proposed are sometimes unclear). Transects would
be “crenellated to cover the entire square”. Where the 1km square may be too small a sampling
area to produce repeatable data, i.e. for more mobile (less territorial) and more gregarious species
such as Fallow and Red Deer, 5km squares are also suggested as the sampling unit if populations
in entire 10km squares cannot be censused. Absolute densities would presumably be estimated
for each survey square. Complete surveys are proposed every seven years, with additional, more
intensive monitoring in the key areas for species’ range expansion. Proposals gleaned from
discussion with deer experts but not used explicitly in the MaMoNet (MMR, p.184) also include
recommendations that at least 2000 1km squares which encompass the known range of each
species plus a 50km buffer zone around the ranges of Roe, Sika and Reeves’ Muntjac should be
covered every five years using 1km transects, and that each square should contain at least one
block of woodland of more than 1ha.

The MMR method has the advantage of being geographically unbiased and is therefore a sound
basic sampling strategy to cover national populations. The statistically robust background to the
design of the MaMoNet is a further advantage. The use of absolute densities as a “common
denominator" also allows the results of disparate monitoring methods to be combined meaningfully. In practice, this could represent the only way in which an internally consistent national system for the monitoring of deer could be designed. However, there are several problems with the approach proposed, most of which are practical. First, the method ignores the large amounts of high quality data which are already being collected for deer populations in some habitats or regions (see above), which must at least be inefficient. Second, having methods which are not fully standardised but require a professional assessment of the action needed to measure the densities of all species found in a given 1km or 10km square restricts the survey work to highly qualified surveyors. Third, where good data are being collected, the available pool of surveyors (if professionals are not to be used) would be asked either to add to their existing work or to replace it; this is unlikely to be popular when the new data are likely to be of less use, locally, than those already being collected. Fourth, considerable concern has been expressed about the reliability of pellet count methods (S. Harris, pers. comm.). Fifth, the MaMoNet concept is centred on the idea of national monitoring and, ultimately, single species-specific figures for population changes. Like those of many other mammal species, deer populations are probably not mobile enough to mix to such an extent that the whole of Britain or of the UK can be meaningfully considered to hold a single, homogeneous population. It might therefore be more desirable to monitor deer species according to biologically meaningful divisions and to combine the results of such monitoring schemes if and when it is required politically. This would allow the needs of local and national monitoring to be combined.

Combining existing and new schemes - Although the MMR method may be the only way to obtain an internally consistent national survey of deer populations (subject to the methods being ratified), we suggest that this requirement could be relaxed. We consider that the objectives for UK deer monitoring can be met by using the existing monitoring schemes which generate high quality data and by supplementing them with new survey information which fills the geographical and species gaps in the current monitoring spectrum. Current deer monitoring probably covers most of the ranges of Red, Sika and Fallow Deer effectively through the schemes run by the Deer Commission for Scotland, Services Branch of the British Deer Society, Forestry Commission and Exmoor Deer Management Society. British Deer Society cull data provide further monitoring information on distributional changes. Several options exist for the monitoring of the other species and areas. Most accurate would be dedicated deer surveys, which would have be species-specific and to be conducted in winter. For open hill species (almost always Red Deer outside Scotland), direct counts of large randomised survey areas (say, 2×2km tetrads) would be the best method and could be conducted by volunteers. For woodland species, expert opinion is divided, suggesting that further discussion and pilot work is necessary to identify methods which are widely acceptable. One option is to use faecal pellet count methods (either FSC or FAR methods according to the availability of resources and distribution of sample sites: Mayle & Staines 1998), working on small plots (a minimum of 10×10m) or transects (say, 1km). Different transect lengths or plot sizes would be most appropriate for species with different social behaviour (e.g. Roe and Fallow Deer), but compromise may be needed to allow such species to be monitored by a single scheme (such as an adjunct to our proposed Sign Transect Survey: Section III.B.2). The considerable difficulties with pellet identification mean that professional surveyors would probably be required to conduct these surveys; volunteers could be trained to make the identifications (perhaps with professional support by post in difficult cases) but deer pellets are not currently covered by The Mammal Society’s Look Out for Mammals courses. However, even professional surveyors may be unable to identify a sufficient proportion of the pellets they find for monitoring to be effective, especially in areas with which they are unfamiliar. The alternative approach is to use a dedicated visual transect method, with routes designed to maximize encounter rates (i.e. concentrated in
late evening/early morning and directed along woodland rides and edges). Such an approach would need research into the specifics of its design to optimise the monitoring of each species and the concerns with habitat-specific differences in detectability would have to be addressed.

Less accurate information, but sufficient at least to monitor changes in range, could be obtained at much lower cost from the general, multi-species schemes suggested elsewhere in this report: the Breeding Bird Survey (Part III.A.1), Mammals on Roads surveys (Part III.B.3), Winter (visual) Transects (Part III.B.1), Sign Transects (Part III.B.2) and Garden Mammal Watch (Part III.B.5). In addition, simple sightings data, solicited from key potential range expansion areas for Roe Deer, Reeves’ Muntjac and Chinese Water Deer, through county Wildlife Trust magazines (for example), would give information on distributional change. None of these might be ideal individually, but each would be subject to different biases and sources of error such that patterns common to a number of survey schemes would be highly suggestive of genuine changes.

Before the implementation of such new schemes, the principal requirement for coordinated national deer monitoring is a body which can collate the data collected by the specialist deer organisations and combine them with information from the general mammal or deer-specific schemes. Such a body would also be best-placed to administer the latter. It might be most efficient for this overall monitoring organisation to form part of whatever body oversees general mammal schemes such as a Winter Transect Survey, and it could be as small as a single individual working within such a body. The coordinating work should be co-supervised by a committee drawn from the various groups interested in deer, or at least by a combination of Deer Initiative and Deer Commission for Scotland representatives, and significant input from scientists in the deer research community should be incorporated.

The coordination work would involve combining region and habitat-specific data from the modular system outlined above. It may not be biologically meaningful to combine data from disparate schemes monitoring different areas, so it should be acceptable to index populations from different habitats and/or regions separately. However, if a combined index is required (for example, for national biodiversity targets), the deer monitoring coordinator(s) could calibrate the individual surveys using habitat- or region-specific estimates of density and construct some kind of meta-index.

27.5 RECOMMENDATIONS

1) The amount and quality of information required from monitoring work on each species must be decided as a first priority. This will then determine the need for new survey schemes to be established and the extent to which existing schemes meet the objectives of monitoring.

2) The second priority is the establishment of a national coordinating body for deer monitoring, perhaps through collaboration between the Deer Initiative and the Deer Commission for Scotland. This body, ideally through staff within a national mammal research organisation, would collate the data collected under existing schemes, set up and administer any new surveys required and combine the information into indices or summaries addressing national deer monitoring aims. This work should require no more than one full-time post within an umbrella mammal monitoring organisation.
3) Significant proportions of the British populations of the larger deer species are already monitored well. Cost-effective and efficient national monitoring would best be served by promoting the continuation of these schemes and by making efforts to collate the information generated centrally. It is important that the needs of national monitoring do not impinge on extant, more local schemes which have been designed with the needs of local monitoring in mind.

4) New survey schemes will be necessary if the populations of deer (especially outside Scotland and of the smaller species) not found on land which is currently the subject of survey work are to be monitored effectively. These include much of the populations of Fallow Deer, Roe Deer, Chinese Water Deer and Reeves’ Muntjac. We have outlined two possible general approaches for the monitoring of these populations. If detailed information on complete populations is required, then surveys based on direct counts (open habitats) and on either pellet group counts or deer-specific transects (woodland) should be established, sampling the countryside on a random basis stratified by habitat (say, using ITE Land Cover data). Identifying the best method for surveying woodland deer should be a priority: the conclusions of the most recent methodological review (Mayle & Staines 1998) and the consensus of expert opinion (per S. Harris) are currently at odds, so we cannot provide firm conclusions here. Any pellet-based surveys would require considerable professional input, at least in terms of support for the identification of difficult pellet groups and probably also directly to conduct fieldwork (professional input would not, however, guarantee successful pellet identification). Volunteer input to any survey would best be managed by a central mammal research organisation and could be drawn from the memberships of BASC, The Mammal Society and the British Deer Society. Three to five staff employed over the survey period (which would best be a period of several months in winter) ought to be sufficient to cover (with volunteer assistance) several hundred of each of woodland and open survey plots. A sample size of at least this order would be needed to provide useful information, but precise requirements can only be assessed through trial survey work.

5) If less detailed information than that specified under point 4 is required, data compiled piecemeal from the multi-species schemes we propose elsewhere and from sightings that solicited from key areas of range expansion could be sufficient. We would envisage that the BBS (Part III.A.1), Winter (visual) Transect Survey (Part III.B.1), Sign Transect Survey (provided that pellet identification is not considered too difficult for volunteers) (Part III.B.2), Garden Mammal Watch (Part III.B.5), Nature Reserve Monitoring (Part III.B.4) and Mammals on Roads data (Part III.B.3) could all contribute. Such a system would require significantly less staff time than specific deer schemes: no more than one to two months per year over and above the time needed to run the multi-species schemes themselves. Both this potential approach and that based on deer-specific monitoring would have to be piloted to assess their suitability and to suggest required sample sizes before either one were adopted wholesale.
28. FERAL GOAT *Capra hircus*

Introduced. Series of small (mostly a few hundred or less), isolated populations in the uplands of each of the four countries of the UK and on some sea cliffs. Abundance stable. Bullock (1995) provides much information on the status and management of this species.

28.1 RECENT AND ONGOING MONITORING

No formal monitoring at national level but managers of almost all land on which goats occur in UK monitor their animals to varying degrees of precision using various combinations of direct counts and observations of damage to vegetation. In Wales, CCW lead a formal management plan with the objective of preventing extinctions of goat populations whilst avoiding damage to oak woodlands.

28.2 MONITORING OBJECTIVES

Local monitoring has the objectives of signalling when unacceptable damage to vegetation has occurred or when numbers are increasing to a degree that is believed to threaten vegetation. Goats are easy to observe, to herd with dogs, and to cull, so management is also easy.

Goat populations are so limited in distribution and so widely managed that there is no reason to monitor them as indicators or (generally) as ecosystem components. Their social structure is such that national monitoring should concentrate on changes in distribution.

28.3 POTENTIAL MONITORING TECHNIQUES

**Direct counts** - Goat distribution, and even numbers, are easy to monitor by direct observation.

28.4 POTENTIAL MONITORING SCHEMES

Collation of data from local monitoring would provide sufficient monitoring at a national level.

28.5 RECOMMENDATIONS

We recommend that the conservation agencies ensure that the current informal system, whereby Dr D J Bullock (National Trust) collates information on Feral Goats is maintained and perhaps somewhat formalised. (The field observations are generally provided by those responsible for local land management.) Ongoing collation of readily obtained data would probably be five days work per year. More intensive reviews at perhaps decennial intervals may prove necessary of the annual accumulation of data is insufficient. Regional staff of the country conservation agencies should be encouraged to be alert to the possible establishment of Feral Goats in new areas.
29. FERAL SHEEP *Ovis ammon*

Introduced. Boreray Sheep restricted to Boreray (St. Kilda), unenclosed Soay Sheep to Soay and (through recent introduction) to Hirta (St. Kilda), Holy Island (Arran), Cardigan Island, Lundy Island and Cheddar Gorge.

29.1 RECENT AND ONGOING MONITORING WORK

The Hirta population has been studied in some detail since the 1950s. All other free-ranging populations of Soays, with the exception of that on Holy Island (about which there is no recent information) are managed closely on the basis of almost annual counts. Boreray Sheep are counted opportunistically, mainly by telescope from Hirta (which overlooks the main grazing slope.)

29.2 MONITORING OBJECTIVES

The demographic studies on Hirta have scientific objectives, based on this being such a detailed long-term study. More generally, local monitoring has the objectives of managing populations for the benefit of vegetation and of preventing animal welfare problems that could arise from overstocking. (Feral Sheep are not readily herded but they are easy to cull by shooting).

Sheep populations are so limited in distribution and so widely managed that there is no reason to monitor them as indicators or (generally) as ecosystem components. Their social structure is such that national monitoring should concentrate on changes in distribution.

29.3 POTENTIAL MONITORING TECHNIQUES

**Direct counts** - Feral Sheep live in open habitats and are easy to observe.

29.4 POTENTIAL MONITORING SCHEMES

Collation of data from local monitoring and scientific studies would provide sufficient monitoring at national level.

29.5 RECOMMENDATIONS

1) We suggest that individual country conservation agencies should routinely collate the data obtained about Feral Sheep populations and that appropriate regional staff should be encouraged to be alert to the possible establishment of new populations (given that Soay Sheep are widely kept in captivity).

2) Resource requirement: two or three man-days work per year for each country conservation agency to ensure that data are centrally collated and to alert regional staff to the possible establishment of new populations. (The latter should be combined with alerting them about the need to gather information on occurrence of various species beyond their known range.)
30. RED-NECKED WALLABY *Macropus rufogriseus*

Introduced. Frequently released or escapes. Populations have persisted for decades but 20-30 animals on Inchconachan (Loch Lomond) and perhaps 50 on the Isle of Man are the only currently viable populations. At least one animal has reached the mainland from Inchonachan. The reproduction rate is low, the animals are vulnerable to road traffic and hard winters, and they may not compete well with ungulates.

30.1 RECENT AND ONGOING MONITORING WORK

Dr D W Yalden has studied the Peak District population for c. 30 years (Yalden 1988) and there has been one study of the Inchconachan population (Weir *et al.* 1995).

There seems to have been no published work on the Manx population but Chris Sharpe (pers. comm.) has supplied the following information. The population inhabits an extensive area of “curragh” willow scrub (grid reference SC3694/95), largely owned by The Manx Museum and National Trust; it may number 50 animals (10 have been seen in a single group) and occupies an area of about 1km$^2$; it may be increasing. It originated from escapes from a wildlife park, probably in the late 1960s. There is no formal monitoring, all the above information being derived from casual observations.

30.2 MONITORING OBJECTIVES

Assuming that the current aim is neither actively to eliminate nor to maintain wallaby populations in the UK, we suggest that the monitoring objectives for this alien species should be:

1. to record the establishment of any new populations;
2. to monitor the size and range of such populations, especially to detect any sustained increase.

30.3 POTENTIAL MONITORING TECHNIQUES

**Direct counts** - Wallabies are secretive (and small populations are therefore easily overlooked) but populations in small areas can be counted by sweeping the area with a line of counters - 45 people were used to cover the 45ha of Inchconachan.

**Field signs (droppings)** - Wallaby droppings are fairly easily identifiable and are thus a useful means of confirming continued presence in an area; but they are unlikely to be sufficiently noticeable to provide alerts to the presence of Wallabies in previously unoccupied areas.

**Field signs (tracks)** - Wallaby spoor is so different from that of any British animal that naturalists alert to the possibility of the species escaping or being released may notice it. It is a useful means, particularly after snow, of confirming the species’ continued presence in an area.

30.4 POTENTIAL MONITORING SCHEMES

See below.
30.5 RECOMMENDATIONS

1) Inchconachan - There is no need to devote resources to monitoring this population but SNH should collate any information that is obtained about it. Resource requirement: a few hours per year.

2) Loch Lomond - Local SNH staff should be aware of the possibility of animals emigrating from Inchconachan. They should know what wallaby droppings and spoor look like. They should collate all reports of sightings and signs. They should follow up such reports, to establish the number and exact locations of any animals observed.

Resource requirement: virtually none, unless reports need to be followed up, which may take a few man days.

3) Isle of Man - The Manx Museum and National Trust could perhaps take the lead in systematically collating sightings of these animals. Local ornithologists maintain a systematic programme of work on part of the site and could perhaps maintain systematic records of wallaby sightings. The extent of the area occupied should be assessed every few years by a survey using sightings and field signs. It would be useful to have a base-line assessment of numbers, by organising a large team of drivers to cover the area thoroughly, as was done on Inchonachan (Weir et al. 1995).

Resource requirement - depends on scale of work but collation of sightings should take no more than a few hours per year and surveys of the area occupied only a very few man days each.

4) Other established populations - Assuming, as is likely, that other populations of wallabies are occasionally established, their size and range should be monitored. We suggest that, given the slow reproductive rate of the species, surveillance at intervals of, say, five years would be adequate, consisting of surveys to determine the area occupied (by means of searching for animals, droppings and tracks), followed by intensive sweeps of the area by a large team during a single day, to determine numbers.

Resource requirements: perhaps two-man-months of professional time to organise and report on each survey; some dozens of volunteers would be needed for the sweep of the occupied area.

5) Alien mammals scheme - This should be used to monitor occurrences of this species.
31. UNESTABLISHED ALIENS

Large numbers of alien species (and sub-species) are kept in captivity in Britain, as exotic pets as exhibits in zoos and wildlife parks, and as farmed animals. Escapes and deliberate releases are not uncommon (Baker 1990). In addition to the non-native species that are currently established (and which are individually considered in this report), this has resulted in the establishment of populations of Muskrat (*Ondatra zibethicus*), Himalayan Porcupine (*Hystrix trachyura*) and Coypu (*Myocastor coypu*); all were eliminated, though in two cases at great cost.

In order that the potential establishment of aliens should be properly managed, monitoring should be conducted of the occurrence of all alien mammals at liberty in the UK. Dr Simon Baker (FRCA) currently runs a low-key monitoring scheme for MAFF, for all alien mammals except common small pets such as Golden hamster *Mesocricetus auritus*; most of his records come from FRCA colleagues and Mammal Society members. Some occurrences probably go unrecorded because of the low level of publicity afforded to this scheme.

31.1 RECOMMENDATIONS

The FRCA scheme should be strengthened, through a systematic publicity programme to a target audience (too wide publicity could result in large numbers of dubious and unverifiable records of “The Beast of Bodmin” sort). This would include more frequent publication of results.

Resource requirements: a few man-weeks per year.
PART V BUILDING THE VOLUNTEER NETWORK

1. INTRODUCTION

The UK has the most highly developed system for conservation-related research and monitoring of birds in the world. This is largely because of the substantial input of fieldwork by volunteers. Similar work is also undertaken for other taxa, albeit on a smaller scale. In respect of the monitoring of mammals, the key question is whether the volunteer input can be developed enough to enable the UK to put into place an effective and affordable programme.

From earlier parts of this report and from MMR, one gains some appreciation of the major contribution that volunteers have already made to the study of mammals in Britain and Ireland. Most of the major surveys have involved a considerable input from the volunteers. Another impressive example comes from surveys of vespertilionid bats (scarcely the easiest group of mammals to study). Volunteers covered 1,030 1x1km squares stratified by Land Class; and the result was two major papers in the *Journal of Applied Ecology* on the foraging habitat preferences of the bats and on the relationship of their abundance to geographical factors, to Land Class and to habitat (Walsh & Harris 1996 a, b). There is clearly a lot that volunteers can do.

We begin this part of our report by briefly reviewing why one should use volunteers for wildlife monitoring and the potential problems with doing so. We consider the support needed from professionals, given that volunteers cannot do the whole job. We review how many volunteers there might be for the monitoring of mammals and we discuss how the volunteer network can be developed through training and through good systems of communication and feedback to volunteers on the work that they do. The volunteer input has to be organised: we make the case for this to be done by a membership organisation, to which many of the volunteers would belong (or, to put it another more important way) which would belong to many of the volunteers. We address how to organise the volunteers and their work at local level, and the special problems that there are in sparsely populated areas. Finally, we address the question of payment to volunteers, sometimes seen as a way of overcoming difficulties of recruitment especially in the sparsely populated areas.

2. WHY USE VOLUNTEERS FOR WILDLIFE MONITORING?

2.1 Citizen participation

There is great value in a democracy in citizens actively participating on a voluntary basis in work that is for the benefit of the whole community.

2.2 Building up a body of committed enthusiasts

The involvement of citizens in conservation-related fieldwork gives them an understanding and commitment to wildlife conservation that is deeper and more soundly based than that they are likely to get simply from reading or hearing about conservation problems.

2.3 Large numbers

Because volunteers are available in large numbers, it is possible to carry out surveys over a wide geographical area potentially in a short period of time. Thus, 1,000 volunteers can easily deliver
five man-years of work in a single weekend. The concentration of work into a short time frame may often be necessary in monitoring and can be impossible to deliver with professionals simply because not enough of them are available.

2.4 Knowledge of local areas

Volunteers can build up an intimate knowledge of their local areas in a way that professionals covering much larger areas cannot. Furthermore, they can provide long term continuity in those local areas, which may be important for effective monitoring.

2.5 Reduced dependence on individuals

If a monitoring programme depends on a single professional, it can be seriously interrupted at short notice should the professional fall ill or move to a different job. Because there are a large number of volunteers there is an overall continuity of effort, even though individuals might drop out of a work programme. Furthermore, there is a long-term continuity of expertise in the body of volunteers even though there may be a gradual turnover of individuals. In contrast, if an individual professional carries out a survey of a species, that same person is unlikely to be available in five or ten years time when the repeat survey is conducted, leading to a loss of the experience that is important in long term monitoring work.

2.6 Guaranteed commitment

“The best assurance that the fieldwork shall be accurate is that the investigators are thoroughly trained in their work, are capable, conscientious, and keen.” (Yates, 1981)

We deal with training and ability below. Here we point out that volunteers, by their very nature, are bound to be conscientious and keen. This means that if they do the work at all then they can be relied upon to do it to the best of their ability. It is true that a proportion of volunteers in a survey may fail to do the work because unexpected commitments interfere with it or because it turns out to be more arduous than they anticipated. They are unlikely, however, to pretend to do the work to the required standard when they have not. In contrast, while the majority of professionals are at least as conscientious and keen as the volunteers, there is always the possibility that a small proportion of them are not conscientious and, in order to maintain their employment, pretend to have done work that they have not actually done (or at least pretend to have done to standards higher than those that they actually operated). While we have no reason to suppose that this has ever undermined the integrity of national surveys of wildlife, the risk is always there.

2.7 Saving in costs

Volunteers do not need to be paid. Most of them live close to where they conduct the fieldwork and are willing and able to cover their travel costs. In contrast, professionals need to be paid and may have to travel long distances in order to undertake fieldwork. As a result, surveys in which the majority of the fieldwork is conducted by volunteers can achieve many times the level of work for a given expenditure on professional organisation than can surveys which are wholly dependent on professionals. This is an obvious advantage of using volunteer fieldworkers, but it is important not to over emphasise it in relation to the other benefits of using volunteers that we have covered here.
2.8 Establishment of protocols

“In order that common standards shall be achieved throughout the survey (which means that over the course of time of monitoring work) it is important that all the survey forms and explanatory material that are to be used by fieldworkers are carefully designed and thought out” (Yates, 1981). This is just as true for professional fieldworkers as for volunteers. Our experience with using volunteers is that one is forced to pay particular attention to these issues because the volunteers quickly come back with questions if the forms or the instructions are unclear. As a result, if another takes over the survey in later years, they may be unaware of procedures adopted by their predecessors because these procedures were in their predecessors heads rather than being recorded on paper. Thus volunteer based surveys, by forcing one to be more explicit about instructions, have a long-term advantage in ensuring that common protocols are adhered to.

3. POTENTIAL PROBLEMS WITH USING VOLUNTEERS

3.1 Level of expertise

Some volunteers may have less expertise than professional surveyors. It must not, however, be forgotten that some volunteers in national wildlife surveys and monitoring are professional ecologists carrying out these surveys in their spare time. Nor must it be forgotten that many amateurs have very considerable field experience with skills equalling, or indeed exceeding, those of many of their professional colleagues. The key issue is field skills and since these are rarely taught as part of the education of professionals, academic qualifications, however sound, are no guarantee of requisite field skills.

Training can overcome the problem of insufficient field expertise for amateurs, just as it can for professionals. Of course, since individual amateurs do less work than those professionally employed to carry out surveys, the training of amateurs tends to result in fewer man-hours of subsequent fieldwork per hour of training than does the training of professionals. However, the Look Out For Mammals project (Section 6) shows that training of amateurs can be carried out at relatively low cost. Indeed, amateurs are prepared to pay often significant fees in order to obtain training in the work for which they have so much enthusiasm.

3.2 Numbers

It may not always be possible to recruit enough volunteers, especially in sparsely populated areas, to undertake the level of survey work that is required. Recruitment can, however, be considerably enhanced by investing professional time in building up a team of committed volunteer fieldworkers for the monitoring work. This is one of the reasons why a professional infrastructure is needed for a monitoring programme where much of the fieldwork is carried out by volunteers (Section 4).

3.3 Cost-effectiveness

Given the need for training and for the building of teams of volunteers which take professional time, some survey work is certainly more cost-effective if done largely by professionals rather than largely by volunteers. The cost-effectiveness of an amateur versus a professional approach must be assessed on a case-by-case basis.
3.4 Availability

Survey organisers sometimes worry that volunteers may not always be available at the times when they are needed. After all, volunteers are carrying out the work in their spare time on which there are often many competing demands. BTO experience is that this is a minor problem. It is certainly outweighed by being able to concentrate many man-hours of volunteer work into a short period because of the availability of large numbers of volunteers. This is a major problem with conducting surveys using professional fieldworkers since the best time of year for conducting a survey may be a relatively short season so that it is simply impossible to recruit enough professionals to do the work within that short time.

3.5 Reliability

Some people who have volunteered to cover an area in a survey may not do so. In our experience, this is usually a very small proportion. This disadvantage is compensated for by the fact that those who do go out to do the work will do it to the best of their ability.

4. THE NEED FOR A PROFESSIONAL INFRASTRUCTURE

The history of the BTO is that the amount of work conducted by the organisation increased rapidly after the number of professional staff that the organisation employed had built up to a level that allowed them to provide the requisite support to the volunteers. There are several jobs that need to be done in running survey and monitoring programmes for which professional input is important. They are as follows:

- **Planning** - Professional expertise is needed to carry out the detailed work of planning surveys and to make sure that the best principles of design are used. The professionals may also be needed to carry out trials of alternative methods before a survey is launched.

- **Training** - Training by professional organisers is a good way of ensuring common standards across fieldworkers.

- **Organisation** - There is a great deal of routine office work in organising surveys, from arranging that the necessary coverage is indeed obtained, to producing and distributing the recording forms. Much of this work is not the sort of thing that volunteers wish to do, and much of it demands sustained and intensive input at particular times.

- **Publicity** - Publicity may be needed on a large scale during the launch of a scheme. This demands both time and expertise.

- **Answering fieldworker queries** - Even in the best planned surveys, fieldworkers are likely to come up with queries when they begin to apply the methods in the field because it is difficult to cater for every eventuality in instructions that have been put together before a survey is actually carried out. The value of a professional organiser is that she,
• or he, can be available constantly to answer these questions and can ensure that the
answers to them are the same for all fieldworkers.

• **Collating data** - The collation of large amounts of survey data (including their input into
appropriate computer databases) is a much more demanding task than might be thought.
For long-term work the data have to be stored such that they can be used without
ambiguity in future. This requires both professional expertise and experience if it is to be
done properly.

• **Analysis** - The analysis of data arising from monitoring work requires considerable
statistical and computing abilities that almost inevitably require professionals to carry out
the work.

• **Feedback to the volunteers** - This is an important aspect of building the volunteer
network (see Section 7). It is important that it is done well, and that it is done promptly.
Volunteer survey organisers often do not have enough time available to give the feedback
as quickly as is desirable.

A few volunteers have the expertise, the competence, and the time to carry out the sort of full
time organising work for which one might otherwise employ a professional. The majority of
volunteers, however, either have jobs that prevent them devoting sufficient time to organising
surveys or, if they are retired, they do not wish to undertake such demanding tasks and would
rather concentrate on fieldwork.

Other advantages of professional organisers arise if they work for a body that is responsible for a
suite of mammal monitoring and survey work. Even though there may be turnover of individual
staff in such organisations, there is a build-up of corporate expertise and the development of the
necessary long-term continuity of approach that is needed for successful monitoring. It should
also be noted that, at the corporate level, it is easier to manage professionals than volunteers,
particularly if performance is not up to standard.

5. **HOW MANY MAMMAL VOLUNTEERS MIGHT THERE BE?**

Sources of volunteer manpower for mammal monitoring are various. The chief ones are
probably the established voluntary bodies: The Mammal Society has a growing membership of
\( c.2,000 \) and The Bat Conservation Trust \( c.3,000 \). Both of these have been able to mobilise many
hundreds of volunteers for some of the national surveys of mammal species (as have other people
organising such surveys).

In addition, there are special interest groups who may be able to provide substantial input for
certain species - the 80 groups who belong to The National Federation of Badger Groups, The
British Deer Society, The Game Conservancy Trust, and the British Association for Shooting and
Conservation. BASC, in particular, have a large membership (around 125,000), which includes
the majority of the UK’s professional gamekeepers and many others who are active in the
countryside, such as professional and amateur deer-stalkers. BASC members are perhaps
particularly likely to be interested in (and to possess the appropriate skills for) monitoring key
quarry species, but no formal attempt to gauge this interest has yet been made. Overlap in
membership between BASC and other organisations such as The Mammal Society and the
British Deer Society would have to be considered if volunteer input were solicited from several
bodies.
Some mammalian species or their signs are identifiable by relatively inexperienced naturalists, especially if good identification materials and training are provided. It is likely that there are large numbers of potential mammal surveyors who could be contacted via the Wildlife Trusts, local naturalists societies, etc. Even if such people have no particular commitment to mammal monitoring in general, their interest may be enough for them to participate in an individual survey (perhaps one of the less-demanding). Providing they get the right encouragement, training, and feedback, this may lead on to further surveys and to taking up membership of relevant bodies such as The Mammal Society.

The fact that some mammals are relatively easy identifiable means that it may be possible to recruit a wide range of people working in the countryside into mammal monitoring. The easiest groups are those that work for large agencies, such as The Forestry Commission, The Environment Agency, and SEPA. Such people may well be prepared to participate in surveys of species such as deer, Red Fox, Badger, Wildcat and Pine Marten.

In summary, there are enough potential volunteers for a good national programme of mammal monitoring to be run, provided the professional infrastructure is in place to develop the network.

6. DEVELOPING THE VOLUNTEER NETWORK THROUGH TRAINING

6.1 Why train?

Training improves people’s skills, so improving the quality of their work. Furthermore, it builds their self-confidence, so making them more prepared to participate in surveys and monitoring.

Follow-up questionnaires to 1997 participants in LOFM training courses (see below) showed that in the subsequent year, over 60% had submitted records to their County Mammal Recorders compared with 18% the previous year; over 60% had used new search methods; and 50% had made records of mammal groups that they had not previously recorded.

6.2 Look Out For Mammals Courses

The Mammal Society has run this training project during 1996-9, mounting 60 weekend courses over that period in all parts of the UK. To date, c. 500 people have attended and it is anticipated that the final number will be almost 700 - double what was planned for the project.

These weekend events include:

- talks and practical training on finding, identifying signs and making sightings of mammals, particularly distinguishing difficult groups.
- hands on experience of Longworth trapping
- owl pellet analysis of identification of mammal remains
- demonstration of the new mammal recording software
- training in identifying mammal calls
- access to an extensive collection of skins, feeding remains, droppings and other mammal signs enabling participants to develop recognition skills.
Participants in the courses have the objectives clearly laid out for them and are tested on their level of achievement at the end of the course. Those who successfully graduate from the course are awarded a certificate (accredited jointly by The Mammal Society and the Field Studies Council). This is a good system for producing a cadre of fieldworkers, trained to consistently high standards.

As part of this programme, a team of trainers has been set up. A standardised programme has been developed for training such trainers.

The courses are evaluated by participants and 70% of participants in the 1997 courses said that they would now like to receive more advanced training.

6.3 Further benefits of the LOFM project

- Publication of *How to Find & Identify Mammals* training manuals. Over 1,000 have been sold.
- National Mammal Recorder workshops co-ordinated by the *Look Out For Mammals* project, have provided a forum for debate on Mammal recording issues.
- New versions of specially developed mammal recording software; the LOFT Recording Package, have been circulated. Over 70 systems are now in operation.
- Improved the UK coverage of County Mammal Recorders from 60% to 95%.
- A LOFM national survey of Harvest Mice revealed alarming declines over the last twenty years. This information forms the basis for future targeted surveys and a successful media campaign has targeted farmers who are in a unique position to manage Harvest Mouse habitat sympathetically.
- An additional investigation into survey techniques for recording Water Shrews has tested and established new and effective methods for collecting records of this elusive species.
- Where training courses involve people mostly from one area, they serve a valuable role in building the local team.

6.4 The future

The Mammal Society is now seeking funding to take LOFM forward and to develop courses in monitoring as such, going beyond the simple identification and recording covered in the courses run so far. An Atlas may be produced to focus interest and raise the profile of mammal surveying by volunteers.

7. DEVELOPING THE VOLUNTEER NETWORK THROUGH COMMUNICATION AND FEEDBACK

It is important to give volunteers feedback on the results of their work, both in terms of straightforward descriptions of how many animals have been found and where and in terms of the use that is being made of that information. The chief value of that feedback is to maintain the level of enthusiasm and commitment that is required in order for the volunteers to continue the work that they do.
Feedback is also important in building up the expertise of volunteers. As organisers discover the problems that volunteers are having and the ways in which their work can be improved, they can pass on the necessary messages as part of the feedback.

To obtain both of these benefits, it is necessary to give specific feedback on individual surveys, but more generalised feedback on mammals and their monitoring is also valuable, not only for these purposes, but also for creating a general climate of interest in the monitoring work, and thus for recruiting new participants.

Feedback can take a variety of forms. Newsletters that reach the people who have participated in a survey and potential recruits are perhaps the most important way of reaching a large number of people for a relatively modest outlay of resources. It is important that all participants get newsletters about their work. This can be difficult if people work in groups, only one member of which is known to the national organiser. A web site can also be valuable (particularly for reaching participants whose names and addresses are unknown to the national organiser). Unlike a newsletter, however, it does not force itself on the attention of participants or potential recruits. Nor may it give the same sense of belonging as does a newsletter sent to participants in the survey, a sense of belonging that may be very important in maintaining volunteers commitment to the work (It is true that one can operate a web site with access restricted to the survey participants, but this tends to defeat the publicity objective which is important in terms of recruiting new volunteers).

Meetings between the volunteers and survey organisers are especially important in developing enthusiasm for monitoring work. These may take the form of informal gatherings, with groups of volunteers in a region or more formal workshops. Presenting lectures to local natural history societies, local mammal groups, Wildlife Trusts etc. is valuable for recruitment and can also be used as an effective means of thanking and meeting survey participants as they are likely to be members of such audiences. Short conferences are another effective way of developing the commitment of the volunteers.

Face-to-face contact between professional organisers and volunteers is easier if the professional organisers are not all concentrated in a single office, but are spread across the country. We would urge that serious consideration is given should a body be set up to promote mammal monitoring to having offices in the different countries of the UK. Compared with having a single office this has many disadvantages, such as losing out on economies of scale and on ease of interaction between the staff. It reduces the extent to which the organisation is seen as a focus of interest and to which it becomes a centre of expertise, it can interfere with the integration of and mutual support within the monitoring team. It may also mean, unless the matter is fairly carefully managed, that volunteers in different parts of the UK may be getting slightly but significantly different advice on how to conduct their survey work. Such disadvantages need to be carefully weighed against the advantages of the organisers being seen to have a local commitment and to them being able to meet a greater cross-section of the volunteers on a much more routine basis.
8. THE IMPORTANCE OF A MEMBERSHIP-BASED ORGANISATION

We believe that membership-based organisations are the most effective way of developing a volunteer network for wildlife monitoring.

An obvious advantage of conducting much of the monitoring through a membership-based organisation is that such bodies, through their membership, have good contacts with volunteers. In practical terms, it is very important to have an up-to-date database of the names and addresses of potential volunteers. The law on data protection makes it increasingly difficult to keep lists of people who have not given consent to their names and addresses being held, especially if reasonable effort is not made to keep those lists up-to-date. Membership organisations, by necessity, have to have the arrangements in place both for dealing with data protection issues relating to names and addresses and for keeping their records up-to-date.

The main advantage that membership-based organisations have in running volunteer surveys is that the members of an organisation have ownership of the work that the organisation carries out. This is not only true in a formal sense but also in an informal sense: the members not only have legal ownership of the organisation but they also feel such a commitment to the organisation that they feel that the work that is done is truly theirs. Developing and maintaining this level of commitment requires focused and sustained attention to members concerns. Nonetheless, it is much easier to do where the organisation running the work is one to which the volunteers have made a membership commitment rather than if it is merely some body that has simply asked the volunteers to assist it.

The feeling of ownership is important for three chief reasons. First, it helps to prevent the organisation being seen as some sort of remote body separate from the volunteers themselves. Second, it reinforces the motivation that the volunteers have for the work because they have made a commitment to the organisation through their membership. Third, in a well run membership organisation, the members should be able to have their views heard. This is always true in principle, since the members will be responsible for electing the board of governance of the organisation. If that board works properly, along with its various specialist committees, it should provide an important channel of communication between the members and the staff. It is important that members feel that they are able to make their views heard, both in strengthening their commitment to the work of the organisation and also in broadening the base of expertise that feeds into the organisations work. It is too easy for professional organisers sitting in offices to lose contact with the problems of fieldworkers. In a well run, membership-based organisation, however, the concerns of the fieldworkers can be fed through the proper channels so that they influence the way in which future work is organised.

If the professional organisers of surveys do not respond to the concerns of fieldworkers, then fieldworkers are likely to stop participating in survey work. We believe that, in a membership-based organisation, they will generally make their views clear through the usual channels before they reach the stage of resigning. Furthermore, if they do resign from membership, it will quickly become apparent that the organisation is not satisfying the wishes of its members. This is a powerful form of feedback. In contrast, if a survey is organised by an institution that is not membership-based, then the support of volunteers can slip away almost unnoticed until it is too late.

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We believe that the lessons from the ornithological world, not only in Britain but throughout the world, are that wildlife monitoring works best if it is carried out by a membership-based organisation and less well if it is carried out by private research institutes, universities or governments that try to recruit volunteers without a membership base. Our interactions with amateur naturalists suggest to us that government bodies are at a particular disadvantage in this disregard, being perceived as remote, unresponsive to the concerns of amateur naturalists, unduly influenced by political interests, and as trying to get their monitoring work done “on the cheap”.

9. ORGANISATION AT THE LOCAL LEVEL

From early in its history, the BTO has benefitted from having a network of Regional Representatives. These are volunteers who undertake to organise the Trust’s work at local level. They are usually responsible for a single county, though in sparsely populated areas a Regional Organiser may take on more than one county, and in heavily populated areas it is sometimes advantageous to split a county between more than one Regional Representative.

It is not the function of BTO’s Regional Representatives to organise surveys as such. Rather, they implement the survey organisation at local level. The value of their input is as follows:

• They know the local volunteers, not only those who are members of the organisation but also non-members who are potentially interested in participating in the survey and monitoring work.

• They know which of the local members are reliable because they know many of them personally and, indeed, have often been in the field with them.

• They provide contacts with local groups such as local natural history societies, local bird clubs and county Wildlife Trust branches.

• They know their local areas. This can be important for some surveys, if effort has to be focussed in particular sorts of places or if particular large land-owners need to be approached in a certain way in order to allow access to their land for wildlife surveys.

• They can deal with some of the questions and worries of volunteers and so take pressure off the national organisers of surveys (though it is important to regulate this element of their work to ensure that the same advice is being given by Regional Representatives across the country.

• They provide a focus for feedback to the volunteers and for contact between the volunteers and the organisation as a whole, helping to prevent the organisation as being seen as a remote, professional driven body.

• In some cases, local organisers can be useful in screening survey returns before they are submitted to the national centre. They have the local knowledge to pick up errors that might not be spotted by national organisers and they know more about the ability of individual fieldworkers so that they can judge whether data are likely to be correct. They are also often in a better position to discuss with fieldworkers the quality of their records than would be a national organiser sitting in an office remote from the fieldworkers.
We believe that a similar network of local organisers would not only be valuable for mammal monitoring work, but would also be relatively easy to set up. There is already an almost complete network of County Mammal Recorders. In addition, there are local mammal groups in some areas which provide a particular focus for volunteer mammal studies. It is true that some of the County Mammal Recorders are not particularly active but, given the lack of official support for their activities, it is remarkable that they are as active as they are. In any case, we believe that these sorts of problems can be overcome if sufficient resources are put in to supporting the network. Resources are not only needed to ensure that individual local organisers are effective (by enthusing existing incumbents and by recruiting replacements for ineffective individuals) but they are also needed to support the work of the local organisers. That support may range widely from the provision of office back-up and of such things as display materials, to the training of local organisers in effective ways of carrying out their role.

10. THE SPECIAL PROBLEMS OF SPARSELY POPULATED AREAS

It is almost inevitable that there are likely to be fewer volunteers available in sparsely populated parts of the country. In practice, the problem seems to be smaller than might be thought. In Scotland, for example, where large parts of the country are very sparsely populated, the membership of The Mammal Society is disproportionately large in relation to the population as a whole (and levels of participation in almost all BTO schemes are also disproportionately greater). Similarly, in Northern Ireland where we (and we understand others) have sometimes had problems in recruiting enough volunteer fieldworkers, The Mammal Society has found a particularly strong demand for training courses. It may be that, in the more sparsely populated parts of the UK, people appreciate the need to get involved themselves and not to leave such volunteer work to others. In addition, in these smaller communities people with common interests tend to know each other better than they do in heavily populated parts of the country, so that there is more interaction and mutual encouragement to take up volunteer work of the sort we are discussing. Nonetheless, there is often a problem in getting enough volunteers in the sparsely populated parts of the country and any plans to set up a programme of mammal monitoring must address how this problem can be dealt with.

It is important, in such areas, to demonstrate to people that the work one wishes to carry out is useful in a local, as well as a UK, context since people often have greater commitment to their local area or to their own country than they do to the UK as a whole. This needs to be remembered throughout the process of interacting with volunteers and it is one of the reasons why it is valuable to have contacts at local level and not just through newsletters and conferences that cover the whole of the UK.

The key to recruiting volunteers is persistent encouragement to participate. The means are through meetings with local natural history societies and similar groups, through notices in the magazines of the Wildlife Trusts, through training courses, and so on. This sort of encouragement can best be delivered at a local level, underlining the importance of having regional meetings around the country and events associated with National Mammal Weeks, as well as a good system of regional organisers and, if possible, professional staff located in offices in various places around the UK rather than in just one place. Given that this sort of encouragement to participate is delivered at local level, it is possible to concentrate these activities in those parts of the UK where volunteers are most needed. Doing so can have an important impact on the level of recruitment.
Concentrating recruitment and publicity efforts in the areas of sparse population is unlikely to overcome the problem entirely. One way of mitigating its effects is to stratify the sampling programme for surveys according to the availability of observers. This allows the variation in intensity of sampling in different regions to be allowed for in the analysis. It does not, however, solve the problem that the intensity of coverage in sparsely populated regions may be too low to give satisfactory information on the regional populations of animals.

To attain better coverage in sparsely populated regions than the local volunteers can provide, it is necessary for people from other areas to help out. One way in which this can be done is by mounting expeditions of teams of volunteers from elsewhere in the country. “Earthwatch” is a global example of the way in which volunteers are often prepared not only to participate in working holidays but to pay the costs of doing so, particularly where there is an element of training involved. Since sparsely populated areas of the UK tend to be areas that naturalists from elsewhere find particularly attractive, there are considerable possibilities of covering such areas with visiting teams of observers. We suggest that such arrangements may work best when the organisation responsible for monitoring is able to bring together potential visitors and local volunteers. The latter, with their local knowledge, can undertake tasks such as getting access permission and finding accommodation, so that the visiting volunteers can concentrate on getting the fieldwork done. Even simply putting individuals from elsewhere into contact with the regional organisers in sparsely populated areas can be a useful contribution to increasing the volunteer effort in the sparsely populated regions.

The obvious solution to coverage in sparsely populated areas is to employ professionals to survey them. We believe that this should be a last resort because the response of volunteers may be that their time is obviously not needed, since the survey organisers can afford to pay professionals. If professionals are put into the field, they should have close contact with the local regional organisers so that they are very much seen as part of the local team and not just as professionals drafted in from outside.

It is often advantageous for survey organisers to undertake some of the fieldwork involved in their survey in order that they should understand the practical problems which the fieldworkers encounter and to provide a quality control against which to evaluate the results submitted by volunteers. If this is to be the case, then it is clearly best for their efforts to be especially concentrated in the sparsely populated regions of the country, not only because that helps to fill the gaps in the coverage, but because if they interact well with local volunteers and potential volunteers, then they can build up the enthusiasm that is so important for recruiting and retaining members of the volunteer network.

11. SHOULD DIRECT FINANCIAL SUPPORT BE PROVIDED FOR VOLUNTEERS?

There is no doubt that providing financial support for volunteers could help recruitment, although, depending on the sort of financial support offered, they might no longer be volunteers in the strict sense. Many of the advantages that stem from using volunteers would persist, such as the number of people that could be involved in a survey over a short period of time, and the local knowledge that volunteers have of their areas. The major disadvantage of supporting volunteers financially would be the costs, even if only travel costs and a modest fee were to be paid, this could increase the overall cost of a monitoring programme many fold, even to the point where it might be more cost-effective instead to conduct the survey wholly through professional staff.
Even if it should be judged that the costs involved of providing financial support for volunteers are justified by the likely improvement in recruitment for a particular survey, it is important that the issue is very carefully considered before it is decided to go down the route of making payments. This is because any such system of payment sets something of a precedent with wider implications for wildlife monitoring generally. Payments made in respect of one monitoring scheme may be a cost-effective way of running that scheme but they may, through undermining volunteers’ willingness to participate in survey work without financial support, cause problems for other wildlife monitoring schemes.

It is also worth pointing out that developments in employment law are such that one has to be extremely careful in making payments to volunteers. It is very easy to get into a situation where they are legally to be treated as employees. This may lead to problems in relation to conditions of employment, health and safety, minimum wage and dismissal on the grounds of unsatisfactory performance, or indeed of redundancy.

The arguments against providing direct financial support for volunteers are therefore strong. In general, the equivalent funding spent on providing them with encouragement, support and feedback is likely to be more cost-effective in building up a team of dedicated volunteer wildlife surveyors.

There is one exception to this generalisation, which is that coverage of remote areas may be improved if some funding is available to assist with the travel expenses of volunteers. Even here, however, it is important to be seen to be providing such funds as a special case, with the funding available to support fieldwork requiring special efforts in remote areas. The payments should never be seen to be matters of routine.
PART VI. POTENTIAL RELATIONSHIPS BETWEEN MAMMAL MONITORING AND THE NATIONAL BIODIVERSITY NETWORK

1. THE CURRENT BIOLOGICAL RECORDING NETWORK

Some biological recording is organised through national bodies but much of it takes place through Local Records Centres (LRCs). The distribution of these is, unfortunately, very patchy; the number of effective LRCs is perhaps only 20% of what is required; some parts of Britain have never had an LRC; others have had one in the past but not now. The effective LRCs feed data into the national Biological Records Centre (run by ITE); others do not.

Another important element of biological recording comprises the County Recorders, usually volunteers but sometimes employees of bodies such as county museums, squeezing their recording work into gaps they make between their other duties. Some counties have recorders for a wide range of taxa (sometimes co-ordinated through a county naturalists’ society); some taxa (including, now, mammals) have recorders in almost all counties. As with LRCs, the effectiveness of County Recorders varies widely. Effective County Recorders work closely with effective LRCs, exchanging records systematically.

Ulster, with a Biological Records Centre that covers the whole province, is in a unique position. We address this briefly in section 9.

2. THE PROPOSAL FOR A NATIONAL BIODIVERSITY NETWORK (NBN)

The NBN is currently under development, with the objective of improving the provision of biodiversity information to all those who need it, through better collection, collation, and dissemination. The vision is of a complete network of LRCs (to gather and disseminate data locally), linked with national societies, organisations and schemes that gather or use such information.

Much thought, planning and preparatory work has gone into the proposal but its progress depends on how quickly three things can be achieved: first, completing the LRC network; second, building the links between the elements of NBN in such a way that information is as freely available as possible but with safeguards against its misuse (and with protection of ownership rights); third, funding for the building and operation of what will be an expensive system. It is currently not clear what the time-scale is likely to be, though the wish is to begin expansion from a demonstration phase in 2000 and to complete the national network with comprehensive local coverage by 2010.

This part of our report addresses the part that NBN might play in mammal monitoring. We concentrate on one area in particular: the potential role of the LRCs.

3. THE ADVANTAGES OF BUILDING FROM LOCAL TO NATIONAL

Many naturalists have particular commitment to their local areas. Building up national programmes of recording and monitoring from the local level has the advantage that such local commitment is harnessed. Many volunteers in national schemes, however, also take a pride in making their contribution to something of national significance, so it is important that the local elements are seen to be part of the national programme, not as independent entities.
The enthusiasm of volunteers can also be boosted through direct contact with the organisers of surveys, which is clearly easier if those organisers are locally based. Local centres can, however, only provide a limited range of expertise. Furthermore, it is likely that many, if not all, surveys will need a national co-ordinator if they are to be effective at national level. Thus personnel of local record centres may be seen as no more than intermediaries, with the “real” organiser still being a faceless person based in a distant town.

It should be noted that both of the above advantages of local organisation can be delivered not only through the federation of local work into a national programme (the “bottom-up” approach) but also through the establishment of local contacts for a national scheme (the “top-down” approach).

Local Records Centres could provide an opportunity for volunteers to help with the inputting of data into computerised databases. Not only are more volunteers close to LRCs than to single national centres but volunteers are generally more likely to be interested in inputting their own area’s data into a database managed in that area than in inputting data from unfamiliar areas into a central repository. (Note that we have not addressed the technical issue of whether the packages currently available for biological recording would be appropriate for managing the data from monitoring schemes).

Finally, a bottom-up approach ensures that the projects undertaken are appropriate, both in nature and scale, for local priorities. Suppose, for example, that a county had put the monitoring of Brown Hares into its Local Biodiversity Action Plan but found that Brown Hares were only recorded on a handful of those sites within the county that were included in the sample for the national monitoring programme. If this was so, the national programme would be unable to deliver the information regarded as of local priority. If the national programme was a federation of local schemes, each county could (in principle) ensure that its local needs were fulfilled.

4. THE DISADVANTAGES OF BUILDING FROM LOCAL TO NATIONAL

For most wildlife, especially wide-ranging species like mammals, monitoring is needed at the national level; their conservation management requires policy decisions (and the right administrative and legislative framework) at national level - and thus also require monitoring at national level. While local action may be as, or even more, important for some species it is generally the case that this needs to be set within the right national framework of policy and legislation. What is needed, therefore, is a national programme, adapted to local circumstances as appropriate. Even if a national monitoring programme is required, it would be possible to build this up from the local level. We have presented above the advantages of doing so. There are, however, a number of disadvantages, which we judge to be overwhelming.

A major problem with the bottom-up approach is that different areas may have different priorities, so that the coverage of an individual species (or group of species) may turn out to be patchy nationwide. It may be appropriate, in terms of national priorities to have more intensive efforts in some regions than in others but such appropriate distribution of effort is unlikely to emerge simply from adding together local schemes.

This problem would disappear if the financial and human resources were sufficient to allow good coverage of all species in every county, or even to allow each county both to put in the concentrated effort that was felt locally to be needed on local priority species and to provide coverage of other species adequate for contribution to the national monitoring programme.
Unfortunately, resources are limited. A county that concentrates enough effort on riparian habitats to be able to monitor riverside species precisely at the local level is less likely to be able to find enough further volunteers to do all of the general mammal monitoring needed nationally.

A third problem with the bottom-up approach is that the data can only be interpreted readily at national level if they are gathered using uniform protocols and common data standards. Such are unlikely to emerge without an overarching national organisation.

5. CONCLUSION: MAMMAL MONITORING SHOULD BE CENTRALLY ORGANISED

We believe that a national programme of monitoring can only be delivered effectively if it is centrally organised; the disadvantages of the alternative bottom-up approach (4, above) strongly outweigh the advantages (3, above). Ornithological experience across Europe supports this conclusion. Bird monitoring has been effectively developed in many European countries but not in those where the organisational structure is divided regionally.

Our conclusion specifically with reference to NBN is that it cannot provide the means for collecting data for a national monitoring programme. If the organisation of a survey is the responsibility of a national centre, then the data can be collected satisfactorily without NBN being involved, whether the fieldworkers are professionals or volunteers, though indirect support of fieldworkers may usefully be provided by LRCs (see Section 7, below).

6. CAN NBN CONTRIBUTE IN ANY WAY TO DATA COLLECTION FOR NATIONAL MONITORING?

Our general conclusion does not mean that NBN has no part to play in data collection for national monitoring. In particular, the national monitoring of some species may require intensive local work (e.g. local studies of the more southerly populations of Red Squirrels). There may also be cases where local enthusiasm results in intensive studies that complement the extensive national work (e.g. the new Water Vole study in Somerset). LRCs may be important in either circumstance, providing a focus for local organisation, technical expertise and back-up, and a connection (via NBN) with the national programme.

Should intense local work be planned, it is important (in terms of effectiveness) that it fits in well with the national programme and that it does not detract from national priorities. It is also important, as with all monitoring work, that it has some guarantee of continuity, to avoid resources being wasted. Given the history of so many LRCs, this last point should not be forgotten.

LRC personnel (whether staff or volunteers) can also contribute significantly to national monitoring by encouraging volunteers to participate and by stressing the value of local efforts being drawn together at the national level, to provide the monitoring feedback that will ultimately drive national policy and, thus, eventually, the fate of local wildlife. LRC personnel can also be in the vanguard of training, perhaps going on special training courses themselves and then passing on the skills to local volunteers. Demonstration collections of skins and “signs” would be particularly useful for training potential mammal recorders.
LRCs may also assist national programmes by providing office facilities for volunteers (both fieldworkers and regional co-ordinators). Computing facilities and local data collation (Section 3, above) are obvious examples but even such simple things as photocopying may be useful to some people. For monitoring schemes that involve significant quantities of data being generated by individual observers, it may be cost-effective to ask observers to submit the data electronically; more generally, regional organisers might usefully submit their regional data electronically. In such cases, LRCs may be able to provide the appropriate facilities for the input and transmission of data.

7. USING LRCs AND NBN FOR DISTRIBUTION RECORDS

Rejecting a bottom-up approach to building a mammal monitoring programme does not mean rejecting any role for LRCs. They have a part to play, especially through NBN and especially in terms of distribution records. Such records are useful for identifying locally significant wildlife sites, which is often important for local planning. LRCs are the most effective means of collecting and collating such information; NBN will be an effective means of delivering distributional information collected at the national level to the LRCs.

Even though there are severe problems of interpretation caused by the unsystematic nature of most biological recording, such records have been used both to model the distributions of animals and plants (thus helping us to understand what controls them) and to monitor changes in distributions. LRCs are important for drawing in general distribution records, particularly because they can harness local enthusiasm in a way that a national centre cannot. Those parts of mammal monitoring that require distribution to be monitored will therefore benefit greatly from the involvement of LRCs.

Where the recording of distribution needs to be based on a more systematic approach, as in recent atlases of birds, central organisations is appropriate, to maintain uniform protocols and common standards. LRCs have a role to play even here, however, as one means of linking volunteer observers into the national programme of work.

8. DISSEMINATION OF INFORMATION THROUGH NBN

This is the central objective of NBN. Even if a mammal monitoring programme is organised centrally, NBN will be a highly effective means of delivering information from the central system to LRCs. Site-based records would form the bulk of such information (Section 7, above) but it would be appropriate for LRCs also to be the point of contact between NBN and the public in respect of monitoring results for local populations. This would be important both for the development and promotion of the monitoring programme and for the use of its results at local level.

9. ULSTER: A SPECIAL CASE

The Ulster Biological Records Centre covers the whole province and is well-founded. Furthermore, the ecological, land-use and cultural differences between Ulster and GB are sufficiently great that it might be useful to modify national monitoring programmes for local application there, even at the expense of abandoning the uniformity of approach that is generally so important in national monitoring schemes. Furthermore, there may be advantages in some of the work in taking an all-Ireland approach in Ulster, even if this interferes with a UK approach:
in terms of the effective delivery of conservation science, biogeography may be more important than administrative protocol.

We do not have the expertise to do more than raise these issues and to recommend that they be seriously addressed as part of the planning of a mammal monitoring programme.

10. SUMMARY

1. NBN would not be appropriate as the chief means of data gathering for the national mammal monitoring programme but has important roles in drawing intensive local studies into the national programme and in encouraging and supporting volunteer participants.

2. NBN has an important role in gathering distribution records locally for use centrally.

3. NBN has a major role in disseminating monitoring results.
PART VII PROPOSALS FOR A UK MAMMAL MONITORING SCHEME

1. SPECIES AND SCHEMES

The proposals set out in MMR are based around a single, three-tiered grid design, to which the recommended monitoring techniques are applied. We have not attempted to create a single monitoring scheme for all UK mammals, since we recognise that it is unlikely that a comprehensive scheme will be an affordable option. It would also lead to a lack of flexibility in incorporating pre-existing data collection and in adaptation to constraints such as the available density of volunteers. Instead, we have indicated species-specific monitoring options, combined into multi-species schemes where possible to maximize cost-effectiveness, as described in Parts III and IV. Table VII.1.1 summarises the available monitoring options for each species (as we see them), and the range of species for which each multi-species scheme can contribute useful information. We then indicate likely approximate costs for the various individual schemes and discuss briefly practical considerations for the organisation of our proposed composite mammal monitoring programme.

2. COSTS OF THE PROPOSED SCHEMES

We now present approximate costings for the multi-species schemes proposed in Part III and for a single example of a species-specific scheme, which should be generally applicable to all such schemes described in Part IV and referred to in Table VII.1.1. All costings are based on the experience of the BTO in setting up and operating each type of scheme and of the various staffing requirements that the schemes will incur. They should be taken as estimates: running several schemes in parallel under the control of a single organisation would be likely to lead to economies of scale and some costs are necessarily unpredictable until the details of survey design and the numbers of volunteers participating are known.

These estimates are costed at 1999/2000 rates and all figures exclude VAT.

The total costs are summarised in Section 2.8.

Note that we have not addressed the costs of running some of the more specialised single-species schemes.
2.1 Likely Costings - Additional Data Collation Through the Breeding Bird Survey

The figures presented below are the projected costings associated with the collation of mammal data as a formalised component of the Breeding Bird Survey. The recurrent costs represent approximately a 10% increase on the existing Breeding Bird Survey annual budget.

<table>
<thead>
<tr>
<th>Detail</th>
<th>Days</th>
<th>Grade</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of methods</td>
<td>55</td>
<td>HSO</td>
<td>11,000</td>
</tr>
<tr>
<td>Programming</td>
<td>30</td>
<td>HSO</td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Total Setup Costs</strong></td>
<td></td>
<td></td>
<td><strong>17,000</strong></td>
</tr>
<tr>
<td>Recurrent costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inputting/Printing</td>
<td>15</td>
<td>SO</td>
<td>3,000</td>
</tr>
<tr>
<td>Data Validation</td>
<td>20</td>
<td>HSO</td>
<td>4,000</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>20</td>
<td>SO</td>
<td>3,000</td>
</tr>
<tr>
<td>Feedback/scheme promotion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Recurrent Costs</strong></td>
<td></td>
<td></td>
<td><strong>13,000</strong></td>
</tr>
</tbody>
</table>

Notes:
1. Programming includes simulations on existing data to evaluate sampling requirements and the development of programs to check and analyse the data gathered.

2.2 Likely Costings - Additional Data Collation Through the National Game Bag Census

The figures presented below are the projected costings associated with the collation of data on sampling effort as a new component of the National Game Bag Census. It is assumed that secretarial support and other associated costs are already met as a component of the existing National Game Bag Census protocol.

<table>
<thead>
<tr>
<th>Detail</th>
<th>Days</th>
<th>Grade</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Form design</td>
<td>10</td>
<td>HSO</td>
<td>2,000</td>
</tr>
<tr>
<td>Analysis for setup</td>
<td>20</td>
<td>SSO</td>
<td>5,000</td>
</tr>
<tr>
<td>Promotion of the scheme</td>
<td>40</td>
<td>SO</td>
<td>7,000</td>
</tr>
<tr>
<td><strong>Total Setup Costs</strong></td>
<td></td>
<td></td>
<td><strong>14,000</strong></td>
</tr>
<tr>
<td>Recurrent costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion of the scheme</td>
<td>20</td>
<td>SO</td>
<td>3,000</td>
</tr>
<tr>
<td>Annual reporting</td>
<td>20</td>
<td>HSO</td>
<td>4,000</td>
</tr>
<tr>
<td><strong>Total recurrent costs</strong></td>
<td></td>
<td></td>
<td><strong>7,000</strong></td>
</tr>
</tbody>
</table>
2.3 Likely Costings - Combined Scheme with Winter Transects, Sign Transects and Mammals on Roads

The three schemes (Winter Transects, Sign Transects and Mammals on Roads) could be co-ordinated most cost-effectively by running them in parallel rather than in isolation. This would require the establishment and introduction of schemes on a rolling basis, with one new scheme being established every year until all three were operating in parallel. The costings presented below assume this approach is adopted and include set-up and running costs. The costings are for all schemes together rather than per scheme. We anticipate that the establishment and operation of a single scheme (in isolation) would require approximately half of the sums shown: running all three would allow certain economies of scale.

<table>
<thead>
<tr>
<th>Detail</th>
<th>Days</th>
<th>Grade</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organiser/Publicity</td>
<td>220</td>
<td>HSO</td>
<td>44,000</td>
</tr>
<tr>
<td>Data Manager/Analyst¹</td>
<td>220</td>
<td>SO</td>
<td>37,000</td>
</tr>
<tr>
<td>Secretarial support</td>
<td>110</td>
<td>SEC</td>
<td>12,000</td>
</tr>
<tr>
<td>Scheme workshops</td>
<td></td>
<td></td>
<td>c.10,000</td>
</tr>
<tr>
<td>Travel</td>
<td></td>
<td></td>
<td>c.5,000</td>
</tr>
<tr>
<td>Data inputting</td>
<td></td>
<td></td>
<td>c.7,000</td>
</tr>
<tr>
<td>Mailing/Printing Costs (report)</td>
<td></td>
<td></td>
<td>c.6,000</td>
</tr>
<tr>
<td><strong>Total Annual Cost</strong></td>
<td></td>
<td></td>
<td><strong>121,000</strong></td>
</tr>
</tbody>
</table>

Notes:
1. Some consultancy on analysis techniques and statistical design may be considered appropriate, in which case this would need to be costed into this budget.

2.4 Likely Costings - Mammals on Nature Reserves

The costings presented below assume that a sample of 3,000 nature reserves are included in the scheme. The costs presented are recurring annual costs (30-50% on top of this is envisaged during the initial year).

<table>
<thead>
<tr>
<th>Detail</th>
<th>Days</th>
<th>Grade</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotion of the scheme &amp; feedback</td>
<td>55</td>
<td>SO</td>
<td>9,000</td>
</tr>
<tr>
<td>Data analysis and interpretation</td>
<td>20</td>
<td>HSO</td>
<td>4,000</td>
</tr>
<tr>
<td>Secretarial support</td>
<td>20</td>
<td>SEC</td>
<td>2,000</td>
</tr>
<tr>
<td>Data inputting¹</td>
<td></td>
<td></td>
<td>c.1,000</td>
</tr>
<tr>
<td>Mailing/Printing Costs (report)</td>
<td></td>
<td></td>
<td>c.9,000</td>
</tr>
<tr>
<td><strong>Total Annual Cost</strong></td>
<td></td>
<td></td>
<td><strong>25,000</strong></td>
</tr>
</tbody>
</table>

Notes:
1. Assumes that data are input using an Optical Mark Reader.
### 2.5 Likely Costings - Owl Pellet Survey

The figures presented below are the projected costings associated with the processing of mammal data from a standardised analysis of pellet material. This would involve collection, analysis and submission of material by volunteers, with co-ordination and some validation carried out centrally.

<table>
<thead>
<tr>
<th>Detail</th>
<th>Days</th>
<th>Grade</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-ordination</td>
<td>20</td>
<td>SO</td>
<td>3,000</td>
</tr>
<tr>
<td>Promotion/Feedback</td>
<td>20</td>
<td>SO</td>
<td>3,000</td>
</tr>
<tr>
<td>Data analysis</td>
<td>20</td>
<td>HSO</td>
<td>4,000</td>
</tr>
<tr>
<td><strong>Total Annual Cost</strong></td>
<td></td>
<td></td>
<td><strong>10,000</strong></td>
</tr>
</tbody>
</table>

### 2.6 Likely Costings - One Year Single Species Survey

The costings presented below assume that a single year of fieldwork is required to carry out a survey for an individual species.

<table>
<thead>
<tr>
<th>Detail</th>
<th>Days</th>
<th>Grade</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determination of sampling protocol¹</td>
<td>10</td>
<td>SSO</td>
<td>2,000</td>
</tr>
<tr>
<td>Determination of sampling protocol¹</td>
<td>75</td>
<td>HSO</td>
<td>15,000</td>
</tr>
<tr>
<td><strong>Total Setup Costs</strong></td>
<td></td>
<td></td>
<td><strong>17,000</strong></td>
</tr>
</tbody>
</table>

| Running costs                      |      |       |          |
| Overall running of the project     | 15   | SSO   | 4,000    |
| 50                                  |      | HSO   | 10,000   |
| 110                                 |      | SO    | 19,000   |
| Secretarial Support                | 30   | SEC   | 3,000    |
| Expenses                            |      |       |          |
| (Travel, Inputting Data, Printing Costs) |      |       | 5,000    |
| **Total Running Costs**            |      |       | **41,000** |

**Notes:**

1. This includes examination of suitable methods, simulation of stratification required and associated analyses.
2.7 Likely Costings - National Co-ordination of Mammal Schemes

The costings presented below represent the likely requirement for linking the various schemes at the national level, thereby providing a nationally coherent approach to mammal monitoring. The co-ordinator would also be responsible for the collation of data from existing schemes such as those currently carried out on deer and squirrels. These figures could potentially be reduced by 50% if the national co-ordination was integrated directly into the co-ordination of the three schemes (Winter Transects, Sign transects and Mammals on Roads) approach outlined previously.

<table>
<thead>
<tr>
<th>Detail</th>
<th>Days</th>
<th>Grade</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-ordination of schemes, publicity, etc</td>
<td>220</td>
<td>HSO</td>
<td>44,000</td>
</tr>
<tr>
<td>Secretarial Support</td>
<td>50</td>
<td>SEC</td>
<td>5,000</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td></td>
<td><strong>49,000</strong></td>
</tr>
</tbody>
</table>

2.8 Likely Costings - Total Costs for All Schemes

Setup Costs (where calculated)

<table>
<thead>
<tr>
<th></th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Data from the Breeding Bird Survey</td>
<td>17,000</td>
</tr>
<tr>
<td>Additional Data from National Game Bag Census</td>
<td>14,000</td>
</tr>
<tr>
<td>Mammals on Nature Reserves</td>
<td>Not costed</td>
</tr>
<tr>
<td>Owl Pellet Survey</td>
<td>Not costed</td>
</tr>
<tr>
<td><strong>Total (where costed)</strong></td>
<td><strong>31,000</strong></td>
</tr>
</tbody>
</table>

Annual Recurrent Costs

<table>
<thead>
<tr>
<th></th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Data from the Breeding Bird Survey</td>
<td>13,000</td>
</tr>
<tr>
<td>Additional Data from National Game Bag Census</td>
<td>7,000</td>
</tr>
<tr>
<td>Combined Schemes (Winter Transects, Sign Transects, Mammals on Roads, Mammals on Nature Reserves)</td>
<td>121,000</td>
</tr>
<tr>
<td>Owl Pellet Survey</td>
<td>10,000</td>
</tr>
<tr>
<td>Single Species Survey (includes setup costs)</td>
<td>58,000</td>
</tr>
<tr>
<td>National Co-ordination</td>
<td>49,000</td>
</tr>
<tr>
<td><strong>Total Recurrent Costs</strong></td>
<td><strong>283,000</strong></td>
</tr>
</tbody>
</table>
3. ORGANISATIONAL PRACTICALITIES

There are several issues that need to be addressed, or at least borne in mind, during the development of a mammal monitoring scheme.

3.1 Long-term guarantees

There is no point in setting up any monitoring scheme without some commitment to its long-term continuity. Schemes that are discontinued after a few years are a waste of time and money. They also seriously undermine the enthusiasm of participants, especially volunteers. If a mammal monitoring scheme is set up then those who have undertaken to fund it must be prepared to give guarantees about its future that are sufficiently firm that it would at least cause them severe embarrassment were the funding to be withdrawn. For this reason, it would be better to start with a modest scheme that costs relatively little than a more ambitious and more expensive scheme. A modest scheme can be expanded as it becomes established and if funding is available, whereas an expensive scheme is likely to be more subject to the vagaries of the financial climate.

Another aspect of long-term security is that those responsible for the work should be corporate bodies rather than individuals, so that there is a better guarantee of continuity.

3.2 Security of data

However the programme is organised, raw data and the supporting documentation should be copied and stored in more than one place. The most effective way to do this is to computerise the data, or at least to store its image on CD-ROMs. It is essential to set up the right data curation systems from the start. Indeed, as a one-off investment, data from previous surveys should be computerised where this has not already been done.

3.3 Developing the system

It would be unwise to set up all components of the system at once. Rather, there should be a phased approach, beginning with the most urgent schemes and introducing others after the most urgent are established.

3.4 Comprehensiveness

Consideration should be given to including bats and marine mammals in the overall mammal monitoring system.

3.5 Design and Statistics

A critical part of the design of any monitoring programme is the method of statistical analysis proposed to deliver information with the precision and power required. We have considered these issues with respect to the BBS in Part III.A.1, but many of our remarks there also apply to other monitoring schemes. All of the entries in Table VII.1.1 assume that sufficient sample sizes and effective analysis techniques are in place: these must be dealt with during the initial organisation of any survey and could have large impacts on the time and effort required (for example, to recruit volunteer effort from more sparsely populated areas). Where multiple surveys
are to be considered, the quality of information which is likely to accrue from the combination of surveys must be assessed. This presents a different statistical problem which is considered briefly in Part VIII.4.

3.6 Organisation

There may be large numbers of organisations with potential interests in mammal monitoring, as producers or as users of information; some may be able to provide financial support or staff manpower; others may be able to muster teams of volunteers. All of them need to be drawn together, their different interests recognised, and an overall organisation put in place. We advise against setting up bureaucratic structures; what is need is clear agreement as to what is each body’s role and how these various roles should work together in making the whole system work.

If the decision is taken to base much of the system on volunteer fieldworkers, one or more membership-based NGOs needs to be supported to take the lead in organising the volunteer-based work.

3.7 Geographic aspects of organisation

Thought should be given to whether schemes should be run centrally or from centres in each country (or even in regions of countries).

3.8 Professional/volunteer interface

We have covered many aspects of this in Part V. A further point is that some organisations may have such a particular interest in a species that they are prepared to put time from their own staff into the fieldwork or into its local organisation. If, as a result, these staff are essentially doing work that might otherwise have been done by volunteers and especially if they are covering only some of the work for a survey (with volunteers providing the rest), it is important that they are seen by volunteers as part of the same team as themselves. How this is done will vary from scheme to scheme but its importance should not be overlooked.
PART VIII. DETERMINING THE LIMITS OF CHANGE

1. INTRODUCTION

In Part I of this report we have considered why conservationists should wish to monitor British and Irish mammals. In Part II, we have considered the design of monitoring programmes. These broad issues now need to be brought down to the practicalities of putting together a practical programme for monitoring, based not only on this report and on MMR but on the views of all of those who have an interest in such work. This is not a task for us but in this final part of the report we raise issues that need to be addressed during the planning of a mammal monitoring programme: how one decides what are the priority species, what information is required for each (in terms of both type and precision), and the sorts of pilot work that should be done before the programme of work is finalised.

To set the scene, we quote from Buckland (1993) who, although he was addressing narrower and more local management issues, illustrates clearly how the definition of management requirements is an integral part of conservation science, determining exactly what science and monitoring needs to be done:

To determine appropriate methods for counting deer, or for estimating deer density, it is necessary to define and list management objectives. These objectives should be specific, and tolerances should be specified that determine maximum acceptable departures from the desired objectives. Only then can the value to management of competing methodologies be fully and objectively compared, and experiments carried out to aid this comparison. A strict definition of management objectives enables subsidiary requirements to be identified. For example, if an objective is to ensure that deer population size is maintained below some limit, that limit or “target population” must be determined. This in turn requires that the term target population is precisely defined. For example, it might be that population which maintains current diversity of habitat, or allows habitat diversity to reach a pre-determined level. This then necessitates modelling habitat diversity as a function of deer numbers, if possible by detailed modelling of deer requirements in different habitats, otherwise or additionally by monitoring habitat change and incorporating a feedback mechanism, so that cull sizes are adjusted to ensure convergence to the desired habitat diversity. The detailed “process” modelling allows target populations to be estimated, whereas the feedback approach by default yields an estimate only when habitat stability at the desired diversity has been reached, and the deer population is therefore at the target level. In practice, a combination of these approaches, with greater initial dependence on the process models, and increased use of feedback over time, allows faster achievement of the target population with adjustment of that target if feedback suggests that the initial estimate is poor.

Tight definition of management objectives can lead logically to sophisticated research requirements, as outlined above. However, by specifying tolerances for these objectives, it may become clear that approximate rules of thumb can sometimes replace the process modelling step. For example, data from a number of sites and from various sources may suggest acceptable deer densities by type of forest with adequate accuracy. It is then necessary merely to estimate density periodically (with precision, and hence survey effort, determined from the specified tolerances), and to adjust cull levels if required.
2. HOW SHOULD WE DECIDE WHAT ARE THE PRIORITY SPECIES?

Other things being equal, the species to which most monitoring effort should be devoted are those most in actual or potential need of active management. Of course, other things are not equal: some species may be very easy to monitor, so may be worth a little effort even if of low conservation priority; others may be so difficult to monitor that, even if they are of high conservation priority, it is better to devote the monitoring resources to other species. Nonetheless, determining priorities for conservation management is an essential next step in establishing a mammal monitoring programme. We list here matters that need to be taken into account when priorities are determined. Our list is not in order of importance.

1. Legal and administrative status

If there is a legal or administrative requirement to manage the population of the species, monitoring is essential.

2. Can the species be managed effectively?

Suppose it were to be concluded that the population of American Mink on mainland Britain could not be controlled given the resources available. (We are not arguing that this is, indeed, so). Then there is a little point in monitoring that population for its own sake. There might, of course, be reasons for monitoring it in order to understand its interactions with other species or as an indicator, but those are different matters; it is important to be clear about the issues and not to confuse them.

In contrast, it might be concluded that American Mink populations on many islands could be controlled; if there were reasons for implementing such control, monitoring of these populations would be needed.

3. Taxonomic status

Some conservationists argue that taxonomically more isolated species are more important than those with many relatives, since their extinction would result in a greater loss of total biodiversity. At the species level, this may not be an important criterion for British and Irish mammals. At the intraspecific level it is: many would wish to conserve Soay Sheep and Feral Goats because they are ancient breeds now scarce and rather distinct from modern domestic sheep and goats; however, they are not full species and should therefore perhaps be accorded relatively low priority.

4. Is the species alien?

The introduction of species outside their natural range has had many ecological and economic impacts; it has often reduced biodiversity by bringing about the extinction of native species. Even without such impacts, however, introduction of aliens results in loss of biodiversity - that part of biodiversity (γ - diversity in technical terms) comprising the biotic differences between different parts of the world that depend not on modern ecology but on the accidents of history, such as the absence (before man interfered) of marsupials from Europe or of Fat Dormice from Britain and Ireland.
Note that whether the species is alien does not always have a simple answer. For example, some might argue that the introduction of *Microtus arvalis* to Orkney by Neolithic people should be considered “natural”; we might wish to be more tolerant of House Mice than of Brown Rats because they have been here for a few thousand, rather than a few hundred, years; we might be more tolerant of the Brown Hare than of the American Mink because it has long ago settled into Britain’s ecology, whereas the mink is still causing disruption.

5. **Are the species’ numbers dangerously low?**

We doubt whether any species of mammal native in Britain and Ireland is so scarce that it is likely to become extinct through demographic accidents or inbreeding. The evidence from the establishment of so many species from small introductions and from the persistence of others on islands is that our mammals are able to persist at very low numbers.

6. **Are numbers expectedly low?**

The relationship of animal abundance to body size is one of the most persuasive of ecological generalisations (Peters 1991). It applies to British mammals (Greenwood et al. 1996). Harris *et al.* (in prep.) point out that some species of British mammals (e.g. Pine Marten) are less common than one would expect on the basis of their body size, while others (e.g. Rabbit) are more abundant than expected. They suggest that these departures from expectation should be used to identify species of particular conservation concern, and species interactions that should be considered, to take prioritisation beyond simple rarity and population change.

7. **Current and historical population changes**

If a species is currently declining in numbers, or has undergone a marked decline in the past, then (especially if the decline can be ascribed to human activities) many would argue that the decline should be reversed. People feel that the species’ numbers should be restored to their “natural” level. Given the ecological transformations that man has wrought in Europe over the last 10,000 years, defining what that level should be is impossible in both practice and principle; that does not, however, weaken people’s views that we “ought” to have more Pine Martens, Brown Hares and Water Voles.

Equally, people become concerned if populations are increasing beyond what they regard as desirable or natural.

These views are strongly value-laden but they are also often strongly held. Even when they do not lead to a decision to take action to modify the decline or growth in the population, they may require that the population is monitored, so that the need for management action can be kept under review.

8. **International status**

In addition to domestic issues, international status may be a reason for giving a species priority: Is the species generally rare in Europe? Does Britain hold a high proportion of the European population? Such considerations are often reflected in legislation but the latter should not be the only criterion.
9. Quarry species

Species that are hunted should usually be monitored (if only at the level of the individual exploited populations), to ensure that their numbers are not reduced to levels either that threaten the economic viability of the hunting or that are unacceptable to the public.

10. Health and economic impacts

Some mammals are vectors of human diseases and many others cause economic damage. In contrast, other species are of economic benefit, not just as quarry species but as tourist attractions, for example. It is not always necessary to monitor such species directly. For example, if damage to trees by Feral Goats is monitored and the goats are culled when the damage reaches unacceptable levels, the situation can be well managed - better managed, indeed, than if one monitored the goat population itself and managed it to some target that was considered, perhaps mistakenly, to be appropriate in terms of vegetation damage. In other cases, direct monitoring would be appropriate.

11. Ecological impacts and species interactions

The American Mink is an important predator of the Water Vole and may have been the key factor in the massive decline of the latter. If the Water Vole is to be conserved, we need to understand its ecology and be aware of the changing pressures on it; monitoring mink is thus important for Water Vole conservation, even if not for any other reason. Equally, the impact of grazing by Field Voles and Rabbits and their status as prey of many birds and mammals is an argument for monitoring their numbers.

12. Is the species a useful indicator of the state of the environment?

The way in which the declines of farmland birds have focussed conservation and political attention on the need to reform agricultural policy shows the potential value of using wildlife as indicators of environmental problems.

13. Cultural significance

Some species are culturally important: the Red Fox has played a major part in rural life and economics for many years; the Ship Rat was responsible for the outbreaks of bubonic plague that had so much impact on our history. Some would argue that these species should be conserved for that reason, just like the Magna Carta and great buildings.

14. Public resonance

Some species arouse more public sympathy and interest than others. In a democracy it is right that this should influence conservation action. Furthermore, species that resonate with the public will act as more effective alarm signals than others, if their decline is an indicator of wider problems. For these reasons, the resonance of the species with the public is an appropriate criterion to use when judging the priority of species for conservation monitoring, alongside the other criteria we have listed.
3. WHAT INFORMATION IS REQUIRED?

For some species, we have clearly indicated in Part IV the different monitoring programmes that would be appropriate for different management objectives. In general, however, there is a considerable range of possible objectives, so we have not considered alternative monitoring strategies in detail. It is important that the objectives should be determined for each species before monitoring programmes are defined; otherwise, inappropriate assumptions may be made.

Broad questions to be asked include:

- Do the management objectives require only an overall national monitoring programme or should the work be regionally focussed?

- Do the management objectives make the monitoring of distribution (at least in some areas) more useful (cost-effective) than monitoring numbers?

- How precisely do changes need to be measured?

The last question may perhaps be recast as “What change would be great enough to trigger concern?” but even in this form it is almost impossible to answer other than arbitrarily, especially in the absence of historical records showing the extent of past variations. A key level used in the Biodiversity Action Plan and elsewhere for the purpose of identifying species of conservation concern is a 25% decline over 25 years. Perhaps this should be regarded as a general guideline for the present.

Perhaps, however, 25 years is too long. Should we aim to be able to detect a 10% decline over 10 years?

Suppose that, given the resources available, a potential monitoring scheme is unlikely to be able to deliver the precision required. What should one do? One answer is that there is no point in wasting money on monitoring that is not precise enough. This is, however, too simple. Suppose that one mounted the monitoring anyway and discovered a decline of 20% over the next 10 years; one would be very glad not to have turned down the scheme on the grounds that it would not have reliably picked up a smaller decline. On the other hand, very imprecise monitoring is unlikely to be useful, since declines that are so large as to be detectable by very imprecise schemes are unlikely to occur. Thus the judgement as to whether a scheme is worth mounting depends not only on its precision and its cost but also on the likelihood and likely magnitude of untoward changes. It also depends on how bad these changes would be in conservation and other terms - a 50% decline in Field Voles might be considered to be worse than a 50% decline in Yellow-necked Mice (or perhaps not so bad!). We raise these issues not because we have answers but because they should be explicitly addressed by those who set up the monitoring programme.

4. TRIAL AND POWER ANALYSES

There are two issues which are critical in the design of all monitoring schemes: first, that the measure or index of presence or abundance is related to true presence or abundance in a known way and, second, that the survey sample size is sufficiently large for population changes of the magnitude required to be detected with the required statistical power. (If we are to consider cost-effectiveness, the latter can be extended to include the avoidance of over-powered designs.)
The trial work required to determine relationships between survey methods and population parameters will vary with method and species. At one extreme, direct counts of large proportions of a population (e.g. for Feral Sheep) may require no trialing at all; at the other extreme, detailed investigations of the factors influencing the detection of field signs such as Pine Marten scats may be necessary. Visual count methods can be heavily influenced by factors such as the activity of individuals and vegetation density, whereas the detectability of faecal signs can vary in complex ways with population density (see, e.g., Water Vole species account). In each case, the necessary extent of any trial survey work (calibrating proposed methods against other techniques) should be determined by expert opinion and by consultation of any previous work which has already been done using the method concerned. Educated guesses about the efficiency of some methods may be possible given the results of other work using related techniques: for example, the results of the current National Fox Survey will inform the design of our proposed Sign Transect Survey.

Four parameters need to be known to calculate the sample size of survey sites required for the detection of a population change with a given statistical power: the size of change/trend to be detected, the sampling interval to be employed, the variance which exists between sites in (changes in) abundance (or presence) and the extent to which short-term fluctuations occur around long-term trends. The former two are set (and can be altered at will) by the monitoring body; the latter two need to be measured or estimated. The best approach to investigating the implications of these unknowns is to conduct simulation analyses, informed by as much relevant information as possible.

Information on spatial variation in abundance or detectability will be available from the results of any one-off or longer-running survey. In this way, we ran simulations of future trends in BBS data (Part III.A.1) using estimates of current survey-square-specific abundance and presence effects. Data from past or existing Badger, fox or hare surveys (for example) could be used in the same way (although they would need, in practice, to be computerised). Information on (annual) fluctuations in abundance under a given long-term trend is harder to come by, and can strictly only be measured with long-term survey data (or at least repeated surveys) in which an underlying trend can be determined. In practice, it will be necessary to run simulations on a range of plausible levels of short-term temporal fluctuation and spatial variation where little useful data are available. Clearly, any simulations will be of higher quality and more reliable if more real data are employed: results on the power of future, repeated Badger surveys would be stronger than any on the power of the Mammals on Roads scheme (for which we do not even know mean detection rates as yet).

As well as variations in trend magnitude and sampling interval, simulations might also take into account issues of stratification and the degree of randomisation of survey sites. The former would form a key part of the design of many of our proposed surveys to maximize their efficiency (Part III) and simulation would be a useful approach for the exploration of stratification strategies. Randomisation may also be worth exploring: power is affected if survey sites are not selected randomly (as they were assumed to be in our BBS: Part III.A.1). A scheme such as our proposed Winter Transect Survey, which would probably include an (as yet undetermined) proportion of surveyor-selected transect routes (Part III.B.1), would benefit from simulations investigating the effects of this lack of randomness.

A further issue with respect to statistical power arises if multiple schemes as considered for the monitoring of the same species. Conceptually, it is clear that we would have more confidence in a population change suggested by one scheme if a consistent change were shown by an independent, parallel scheme. Statistically, however, consideration of the relative value of each
scheme and how to quantify it may be necessary. Such consideration could be informed by the literature on “meta-analysis”, which refers to the combination of multiple, independent studies in searches for patterns at a larger scale (Osenberg et al. 1999a & b; Gurevitch & Hedges 1999).

We suggest that each potential scheme for the monitoring of each species should be assessed with respect to the need for trial field survey work, and particularly important areas are identified in the scheme and species accounts (Parts III and IV). For analyses of statistical power, many of the schemes we suggest are based on essentially similar data, so could be addressed by the same simulations, or at least by minor modifications of a basic simulation framework. We suggest that a suite of power analyses which would provide comprehensive coverage of potential mammal monitoring schemes (given that the data required are made available) should be achievable in c. 2 man-months of the time of a statistician.
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Zoe James (Dorset Wildlife Trust)
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References


Gregory, R.D., Marchant, J.H., Peach, W.J. and Wilson, A.M. (1998) Breeding Birds of the
BTO, Thetford.

399, 423-424.

catch as a relative index of Ferret (Mustela furo) abundance in a New Zealand pastoral habitat.
New Zealand Journal of Zoology, 25 (1):

(3): 97-103.


and pelage characteristics of wild living cats in Scotland: implications for defining the ‘wildcat’.

Davies, J.M., Roper, T.J. & Shepherdson, D.J. (1987) Seasonal distribution of road kills in the

Day, M.G. (1968) Food habits of British Stoats (Mustela erminea) and Weasels (Mustela


tunnel design, and trap position on Stoat control operations for conservation management. New

Don, B.A.C. (1985) The use of drey counts to estimate grey squirrel populations. Journal of

Bird Study 45, 129-145.


Easterbee, N., Hepburn, L.V. & Jefferies, D.J. (1991) Survey of the status and distribution of the


Table I.1.1 Action Plan objectives and targets for UK mammals (Anon. 1994).

<table>
<thead>
<tr>
<th>Species</th>
<th>Objectives and Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Vole (Arvicola terrestris)</td>
<td>Maintain the current distribution and abundance of the species in the UK. Ensure that water voles are present throughout their 1970s range by the year 2010, considering habitat management and possible translocation of populations to areas from where they have been lost.</td>
</tr>
<tr>
<td>Brown Hare (Lepus europaeus)</td>
<td>Maintain and expand existing populations, doubling spring numbers in Britain by 2010.</td>
</tr>
<tr>
<td>Otter (Lutra lutra)</td>
<td>Maintain and expand existing otter populations. By 2010, restore breeding otters to all catchments and coastal areas where they have been recorded since 1960.</td>
</tr>
<tr>
<td>Dormouse (Muscardinus avellanarius)</td>
<td>Maintain and enhance dormouse populations in all the counties where they still occur. Re-establish self-sustaining populations in at least 5 counties where they have been lost.</td>
</tr>
<tr>
<td>Red Squirrel (Sciurus vulgaris)</td>
<td>Maintain and enhance current populations of red squirrel, where appropriate, through good management. Re-establish red squirrel populations, where appropriate.</td>
</tr>
</tbody>
</table>
**Table I.1.2** The status and history of British and Irish mammals. Taken from *The Population Review*, *The Handbook* and Yalden, with additional information from *The Atlas*, *The Field Guide* and MMR.

<table>
<thead>
<tr>
<th>Species</th>
<th>Approx. British Population</th>
<th>British distribution</th>
<th>British habitat</th>
<th>British history and trends</th>
<th>Irish status</th>
<th>Further relevant issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedgehog</td>
<td>1,555,000</td>
<td>Widespread on mainland and (often through introductions) on islands.</td>
<td>General, up to tree-line, including in gardens; scarce in conifer woods, marsh, moorland and cereal crops.</td>
<td>Native. May have declined in last 50 years.</td>
<td>Probably introduced but now widespread.</td>
<td>Predator on eggs and chicks of ground-nesting birds; currently causing severe problems on Outer Hebrides (where recently introduced) for machair-breeding waders. Killed by game-keepers. Many killed on roads. Perhaps particularly susceptible to pesticides because they lay down hibernation fat.</td>
</tr>
<tr>
<td>Mole</td>
<td>31,000,000</td>
<td>Widespread on mainland but absent from most islands.</td>
<td>General, up to 1000m, except where soils too shallow. Uncommon in conifer woods, moorland and sanddunes.</td>
<td>Native. No evidence for changes in numbers or distribution.</td>
<td>Absent.</td>
<td>Molehills can cause problems by damaging farm machinery or by causing soil to be taken up by combine harvesters, so moles are widely controlled.</td>
</tr>
<tr>
<td>Common Shrew</td>
<td>41,700,000</td>
<td>Widespread on mainland; absent from Shetland, Orkney, Outer Hebrides, Isle of Man, Scilly Isles and some Inner Hebrides.</td>
<td>General, though scarcer where ground-cover is sparse. Range into arable crops from field margins.</td>
<td>Native. Population trends unknown.</td>
<td>Absent.</td>
<td>May be sensitive to use of insecticides.</td>
</tr>
<tr>
<td>Pygmy Shrew</td>
<td>8,600,000</td>
<td>Widespread on mainland and (perhaps through introductions) most islands, except Shetland and Scilly Isles.</td>
<td>General, especially where there is plenty of ground-cover.</td>
<td>Native. Population trends unknown.</td>
<td>Similar to British.</td>
<td>May be sensitive to insecticides.</td>
</tr>
<tr>
<td>Water Shrew</td>
<td>1,900,000</td>
<td>Widespread in most of mainland but patchy in N. and W. Highlands. Absent from Shetland, Orkney (apart from 3 records from Hoy 1847-1964).</td>
<td>Habitat preferences poorly known. Mainly found near clean, fast-flowing waterways but also near ditches. Frequently use deciduous woodlands and farmland hedgerows, but probably not permanently.</td>
<td>Native. Population trends unknown.</td>
<td>Absent.</td>
<td>May be sensitive to water quality and stream-bank management.</td>
</tr>
<tr>
<td>Species</td>
<td>Approx. British Population</td>
<td>British distribution</td>
<td>British habitat</td>
<td>British history and trends</td>
<td>Irish status</td>
<td>Further relevant issues</td>
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</tr>
<tr>
<td>Rabbit</td>
<td>37,500,000</td>
<td>Widespread up to the treeline; on most islands.</td>
<td>Short grassland and heathland preferred. Live in field margins in arable landscapes.</td>
<td>Introduced by Normans. Expansion out of managed warrens was not marked until 18th and 19th centuries. British population probably 60-100 million, perhaps more, in first half of 20th century; myxomatosis reduced population by 99% but there has been a steady recovery of the national population since, with considerable local fluctuations.</td>
<td>Similar to British.</td>
<td>A major agricultural pest, though important for maintaining chalk grassland in places. Important food supply for some avian and mammalian predators and scavengers.</td>
</tr>
<tr>
<td>Brown Hare</td>
<td>817,500</td>
<td>Widespread but absent from NW and W. Highlands and Shetland; introduced to many other islands.</td>
<td>Commonest in open grassland and farmland below 500m, especially cereal-dominated arable landscapes.</td>
<td>Introduced in Iron Age or Roman times. Numbers appear to have declined from 1920s until now, with some recovery in the late 1950s and 1960s.</td>
<td>Widely introduced in late 19th century but remains scarce and localised (only in Fermanagh, Derry &amp; Donegal).</td>
<td>Minor agricultural pest. Minor game species.</td>
</tr>
<tr>
<td>Mountain Hare</td>
<td>350,000</td>
<td>Scottish Highlands, Southern Uplands, Peak District, Isle of Man, some other islands.</td>
<td>Heather moorland (especially grouse moors).</td>
<td>Native to the Highlands; introduced to more southerly regions and islands. Numbers appear to have fluctuated at scales of one to a few decades.</td>
<td>Native. Occupies wide range of habitats, similar to those occupied by both hare species in Britain.</td>
<td>Similar to issues relating to Brown Hare. Well-marked subspecies in Ireland.</td>
</tr>
<tr>
<td>Red Squirrel</td>
<td>160,000</td>
<td>Still present in much of mainland Scotland (except N. and NW.) but only a few relict populations in England and Wales (including Isle of Wight).</td>
<td>Large tracts of conifer forest are prime habitat but also occupy smaller and deciduous woodlands.</td>
<td>Native (though reinforced with introductions). Major fluctuations occurred in Scotland in 19th century. Massively declined in England and Wales during 20th century as a result of competition from Grey Squirrel (especially in deciduous woods) but in Scotland impact of latter mitigated by increased area of forestry. Continuing to decrease as Grey Squirrel spreads.</td>
<td>Probably introduced. Reintroduced in early 19th century, following 18th century extinction. Widespread except in extreme N. and W. but declining as Grey Squirrel spreads.</td>
<td>Causes forestry damage but fully protected.</td>
</tr>
<tr>
<td>Species</td>
<td>Approx. British Population</td>
<td>British distribution</td>
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<tr>
<td>Grey Squirrel</td>
<td>2,520,000</td>
<td>Most of England and Wales (not Scilly Isles or Isle of Wight); central Scotland; parts of E. Scotland.</td>
<td>Woodland, especially mature deciduous, extending out along hedgerows; urban and suburban areas with large deciduous trees.</td>
<td>Introduced widely during half century after 1876. Continuing to increase.</td>
<td>Introduced in 1911. Now occupies about 20% of the country.</td>
<td>Major forest pest. Horticultural and agricultural damage occurs. Has caused massive decline of Red Squirrel. Some householders resent Grey Squirrels taking food put out for birds but many other people in urban and suburban areas gain much pleasure from observing Grey Squirrels. Not a game species in Britain and Ireland, unlike in its native range of N. America.</td>
</tr>
<tr>
<td>Bank Vole</td>
<td>23,000,000</td>
<td>Widespread on mainland but absent from most islands.</td>
<td>Mature deciduous woodland with thick shrub or field layer; also in grassland, hedgerows, conifer woods, deciduous plantations.</td>
<td>Native. No evidence of major population changes, though populations fluctuate nationwide in short-term, perhaps dependent on masting of trees.</td>
<td>Probably introduced accidentally to the south-west, c.1950. Now found in c.20% of the island; still spreading.</td>
<td>Important prey of Tawny Owl <em>Strix aluco</em>, some other birds, and mammals. Populations on Skomer, Mull and Raasay are considered to be subspecifically distinct.</td>
</tr>
<tr>
<td>Field Vole</td>
<td>75,000,000</td>
<td>Widespread on mainland but absent from Shetland, Orkney, many Hebridean islands and Isle of Man.</td>
<td>Mainly rough (especially ungrazed) grassland, including forestry plantations.</td>
<td>Native. There have probably been major population declines as a consequence of loss of preferred habitat; probably as a result, major short-term fluctuations now no longer occur in Britain. Populations rose in 1950s and 1960s, as myxomatosis reduced Rabbits, leading to increased grass growth.</td>
<td>Absent.</td>
<td>Major prey of Weasels, Kestrels and other mammals and birds. Forestry and agricultural damage occurred when numbers were high but is now uncommon. Of the various island forms once considered subspecifically distinct, only that on Islay is currently recognised.</td>
</tr>
<tr>
<td>Orkney Vole</td>
<td>1,000,000</td>
<td>Orkney</td>
<td>Occupy dense grassland, moorland, marsh, plantations and gardens but largely absent from arable land and short pastures (except for field margins).</td>
<td>Introduced by Neolithic people (around 3500 BC or earlier). Has probably declined during recent agricultural intensification, now being confined on farmland largely to linear features (where numbers can be very high).</td>
<td>Absent.</td>
<td>Subspecifically distinct from populations on mainland Europe. Of 5 subspecies formerly recognised on various islands in Orkney, 2 are still considered useful.</td>
</tr>
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<tr>
<td>Water Vole</td>
<td>1,169,000</td>
<td>Widespread on mainland, but absent from most of N. and Highland Scotland and from most islands.</td>
<td>Densely vegetated banks of slow-moving permanent waterways; less common on ponds. Uncommon in uplands. In a few localities live subterraneously, away from water.</td>
<td>Native. Long-term decline during this century; especially rapid in north and west in 1940s/50s and in 1980s/90s (probably because of acidification of streams following acidification and predation by American Mink, respectively, though pollution, habitat destruction, and disturbance may have played a part).</td>
<td>Absent.</td>
<td>None.</td>
</tr>
<tr>
<td>Wood Mouse</td>
<td>38,000,000</td>
<td>Very widespread, even on many small islands.</td>
<td>Rare above tree-line or in very wet places; otherwise fairly ubiquitous, including arable land.</td>
<td>Native. Population trends unknown, though there are short-term fluctuations.</td>
<td>Similar to British.</td>
<td>Susceptible to poisoning by various pesticides and sensitive to herbicide use (which reduces both vegetable and invertebrate food resources). Can cause damage to pelleted seed of sugar beet and to stored food.</td>
</tr>
<tr>
<td>Yellow-necked Mouse</td>
<td>750,000</td>
<td>S. and SE England and border counties of Wales.</td>
<td>Mature (perhaps especially ancient) deciduous woods; less commonly in hedgerows.</td>
<td>Probably native. Certainly present from Neolithic onwards. Archaeological evidence suggests a wider distribution in Neolithic and Roman times; reduction probably result of clearance of woodland. May have declined further during this century.</td>
<td>Absent.</td>
<td>Sometimes damages stored food.</td>
</tr>
<tr>
<td>Harvest Mouse</td>
<td>1,425,000</td>
<td>Most of English mainland except NW and some coastal areas of Wales; scattered colonies elsewhere (probably recent introductions).</td>
<td>Areas of tall, dense vegetation outside woods - long grass, reedbeds, grassy hedgerows and ditches, bramble patches, cereals and some other crops.</td>
<td>Origin uncertain: not recorded archaeologically until Roman times but total archaeological records are few. May have declined in late 19th century with advent of close-cutting reaping machines. Agricultural changes have removed large areas of suitable habitat during 20th century and recent switch to winter cereals means that crops are harvested before peak of breeding season; but no direct evidence of reductions in range or abundance.</td>
<td>Absent.</td>
<td>Vulnerable to agricultural intensification and loss of non-agricultural habitats. MMR suggest that Harvest Mice may be “particularly sensitive to climatic changes at the extreme of their range”; however, that range extends from Japan, across a broad sweep of C. Asia, through most of Europe (not Mediterranean) to Finland, Denmark and N. Spain, with the western bounds apparently determined by the sea.</td>
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<tr>
<td>House Mouse</td>
<td>5,192,000+</td>
<td>Widespread across the whole of Britain, including inhabited islands (less common on uninhabited; St. Kilda subspecies died out following human abandonment of island).</td>
<td>Essentially commensal in Britain, in dwellings, farm buildings and food stores. Populations in arable land do best if sustained by reservoirs from grain stores.</td>
<td>Almost certainly introduced but present in Iron Age (perhaps Bronze Age). Formerly commonest mammal in S. English arable land but probably declined considerably following loss of cereal ricks (consequence of combining) and more effective pest control in buildings. Numbers can fluctuate hugely in short-term, as they build up rapidly when food is plentiful.</td>
<td>Similar to British.</td>
<td>A major pest of stored food. Widely controlled by poisoning.</td>
</tr>
<tr>
<td>Brown Rat</td>
<td>6,790,00+</td>
<td>Widespread, even on small islands.</td>
<td>Commensal, found in farm and other buildings, food stores, refuse tips, sewers and other urban waterways; widespread in arable land, especially in summer. Occupy natural habitats along the coast.</td>
<td>Introduced around 1728. Spread rapidly. More effective harvesting and food storage, combined with modern poisons, have probably reduced numbers dramatically during 20th century though numbers may have increased recently.</td>
<td>Similar to British.</td>
<td>A major pest in food stores. Damage also caused by gnawing. Disease risk, especially leptospirosis (Weil’s disease). Widely controlled (especially in urban areas) by poisoning, though genetic resistance is widespread.</td>
</tr>
<tr>
<td>Ship Rat</td>
<td>1,300</td>
<td>Confined to ports and to Lundy Island (Bristol Channel) at least the three larger of the Shiant Isles (Key et al 1998), and Inchcolm and possibly other Firth of Forth islands (William Penrice pers. comm.).</td>
<td>Warehouses, etc., in dockland areas. Rocky shores and cliffs on Lundy and Shiant.</td>
<td>Introduced in Roman times and continuously since then from ships and (more recently) ferries. Widespread and common before arrival of Common Rat but then declined rapidly; largely restricted to ports by 1900, with further declines since. Most port populations probably dependent on reintroduction.</td>
<td>Only in ports. Probably extinct except for sporadic accidental introductions.</td>
<td>Where common, at least as important a pest as Common Rat. Plague and typhus vector in eastern tropics (and formerly in Europe).</td>
</tr>
<tr>
<td>Common Dormouse</td>
<td>500,000</td>
<td>Widespread but local from mid-Wales, Leicestershire and Suffolk southwards; scattered populations in N. England.</td>
<td>Deciduous woodland with good shrub layer; coppice.</td>
<td>Native. More widespread in N. England in 19th century than now. Appears to have declined in range and abundance in 20th century.</td>
<td>Absent.</td>
<td>None.</td>
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<tr>
<td>Fat Dormouse</td>
<td>10,000</td>
<td>Confined to an area around the Chilterns approx. 20 x 30 km.</td>
<td>Deciduous and mixed woodland (does not require dense shrub layer); orchard and gardens.</td>
<td>Introduced to Tring Park, 1902. Range and numbers slowly increased; continue to do so.</td>
<td>Absent.</td>
<td>Can cause serious forestry damage; locally may be orchard pests. Cause damage in lofts of houses by eating and fouling stored food and by chewing.</td>
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<tr>
<td>Red Fox</td>
<td>240,000</td>
<td>Widespread on mainland but absent from most islands.</td>
<td>Almost ubiquitous.</td>
<td>Native. Reduced in numbers and range (especially in the east) by game-keeping during the 19th century; has recovered, especially in the second half of this century. Now widespread in urban and suburban areas.</td>
<td>Similar to British.</td>
<td>Widely regarded as a pest (mainly because of incorrect view that foxes kill many lambs but also because they take free-range domestic birds and ground-nesting wild birds) but also as a sporting quarry: 100,000 or more probably killed by man each year in UK. Great adaptability and breadth of diet probably make it a poor indicator of the general condition of the countryside.</td>
</tr>
<tr>
<td>Pine Marten</td>
<td>3,650</td>
<td>NW Highlands; patchily in E. and S. Scotland, N. England and Wales. Absent from most islands.</td>
<td>Various: higher densities in woodland but also occurs in pasture, scrub, moorland and coastal sites.</td>
<td>Native. Hunting for sport and pelts, and probably deforestation, made it rare in much of Britain and Ireland by 1800. Continued decline in 19th century (under intensive game-keeping) but recovery in 20th, with continued increase in numbers and range in recent decades in Scotland, NE England and Wales but evidence of recent (post 1966) decline in NW England and N. Midlands.</td>
<td>Patchily distributed. History probably similar to that in Britain.</td>
<td>A predator of rodents, gamebirds, wildfowl and domestic poultry; almost half farmers and one-third of foresters and game-keepers regard it as a pest but others have positive views.</td>
</tr>
<tr>
<td>Stoat</td>
<td>462,000</td>
<td>Widespread. Absent from Orkney, Outer Hebrides and some Inner Hebrides.</td>
<td>Ubiquitous, provided there is some cover (uses cover in field margins in open agricultural landscapes).</td>
<td>Native, though probably introduced to most of the islands on which it occurs. Major reductions occurred consequent on Rabbit decline caused by myxomatosis; at least partial recovery subsequently but game bags of Stoats have declined again during past quarter century.</td>
<td>Similar to British.</td>
<td>Widely persecuted (though probably ineffectively: &gt;75% need to be removed annually to reduce population). Rabbit is main prey in Britain. Irish population regarded as subspecifically distinct.</td>
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<tr>
<td>Weasel</td>
<td>450,000</td>
<td>Widespread on mainland but Skye, Anglesey and Isle of Wight are only major islands on which it is present.</td>
<td>Ubiquitous, though less common where small mammals scarce.</td>
<td>Native. Population boomed after myxomatosis, dependent on large numbers of small mammals living in grass that was freed from constraint of Rabbit grazing. Game bags indicate decline since early 1960s, especially in E. England.</td>
<td>Absent.</td>
<td>Widely persecuted as perceived enemies of gamebirds (of which they take chicks, though main prey are small rodents). May be indicator of healthy populations of small mammals. Irish population regarded as subspecifically distinct.</td>
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<td>Polecat</td>
<td>15,000</td>
<td>Most of Wales; border counties of England; spreading into Midlands.</td>
<td>Widely distributed in woodland, forests, farmland, marshes and coasts; less common on high ground.</td>
<td>Native. Probably once widespread in Great Britain but by 1915 persecution had reduced to an area around Aberystwyth of about 60 km radius. Gradual recovery since, especially in last 50 years, as persecution relaxed.</td>
<td>Absent</td>
<td>Takes a wide variety of vertebrate prey (including poultry and Pheasants).</td>
</tr>
<tr>
<td>Feral Ferret</td>
<td>2,500</td>
<td>Established on Shetland, Harris, the Uists, Islay, Mull, Isle of Man and in a few mainland sites - though mainland populations tend to be ephemeral.</td>
<td>Little studied. Occupies moorland on Mull.</td>
<td>Repeatedly introduced, largely by accidental escapes.</td>
<td>Apparently absent</td>
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<tr>
<td>American Mink</td>
<td>110,000+</td>
<td>Most of mainland Britain and many islands, though not yet Orkney and Shetland (Mike: the latter needs checking).</td>
<td>Wide range of aquatic (including coastal) habitats but may move away from water if terrestrial prey abundant.</td>
<td>Introduced through escapes, though not establishing until 1950s. Spread rapidly through natural increase and deliberate releases. Spread north in Scotland has slowed but continues, still increasing in East Anglia.</td>
<td>Similar to British.</td>
<td>Thought to be largely responsible for decline of Water Vole. Devastating impact on seabirds that nest on flat grounds, such as terns. Local pest at fish-farms, on poultry farms, and Pheasant pens. Probably competes with Otter but actual impact of each species on the other is the subject of debate.</td>
</tr>
<tr>
<td>Badger</td>
<td>250,000</td>
<td>Widespread but absent from much of N. Scotland, Shetland, Orkney, Hebrides and Isle of Man.</td>
<td>Fairly ubiquitous but less common in open country and on high ground.</td>
<td>Native. Reduced by persecution in 19th century; general increase in 20th century, with some local setbacks as a result of dieldrin poisoning in 1960s.</td>
<td>Similar to British.</td>
<td>Can be a nuisance to farmers and horticulturalists. May be important reservoirs of bovine TB, though some argue that cattle are the reservoirs for Badger TB; experimental culling in progress.</td>
</tr>
<tr>
<td>Otter</td>
<td>7,350+</td>
<td>Widespread but absent from much of central England and central belt of Scotland and from Anglesey, Isle of Man, Isle of Wight.</td>
<td>Inland and coastal waters of all sorts.</td>
<td>Native. Reduced by persecution and hunting in 18th and 19th centuries; some recovery in first half of 20th century. Massive drop in numbers and reduction in range after 1950s in England and Wales (less so in Scotland) as a result of organochlorine poisoning.</td>
<td>Widespread. Similar history to Britain in terms of persecution but, as in Scotland, largely escaped pesticide problems.</td>
<td>An indicator of pesticides and pollution of waterways. Probably much less of a fisheries pest than was formerly believed. Irish population may be subspecifically distinct.</td>
</tr>
<tr>
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<tr>
<td>Wildcat</td>
<td>3,500</td>
<td>Scottish Highlands.</td>
<td>Relatively low altitudes in the Highlands. Woodland, forest, open hill ground.</td>
<td>Native. Has potentially interbred with Feral Cats for hundreds of years, so present-day genetic status is in question. Whether a morphologically distinct “Wildcat” can actually be identified today is in dispute (Ballharry &amp; Daniels 1998, Daniels et al. 1998; Kitchener 1995).</td>
<td>Native but became extinct during Neolithic.</td>
<td>The most northerly population of this species in the world. May be threatened by hybridisation with Feral Cat.</td>
</tr>
<tr>
<td>Feral Cat</td>
<td>813,000</td>
<td>Widespread, even on some currently uninhabited islands (e.g. Monach Isles).</td>
<td>Various, especially close to human dwellings.</td>
<td>Introduced. Given difficulties of distinguishing archaeological remains from those of Wildcat, time of introduction unclear; possibly Roman, more likely Norman. History of population equally unclear.</td>
<td>Similar to British.</td>
<td>Perhaps largely dependent on Domestic Cat population as source of recruits in some areas. Given numbers, probably an important predator in the countryside. (Have caused major problems on many oceanic islands).</td>
</tr>
<tr>
<td>Wild Swine</td>
<td>200+</td>
<td>Kent/East Sussex; Dorset</td>
<td>Deciduous Woodland, moving onto agricultural land to feed.</td>
<td>Native but probably extinct in 13th century. Recently re-established from escapes.</td>
<td>Native but extinct by historic times.</td>
<td>Major game species on continent. Agricultural damage can be severe; disease risk to domestic pigs.</td>
</tr>
<tr>
<td>Red Deer</td>
<td>360,000</td>
<td>Scottish Highlands, Hebrides, SW Scotland, Lake District, SW England, Breckland; small scattered population elsewhere in England and Wales.</td>
<td>Probably originally a species of open woodland and forest edge but Highland, Hebridean and SW English populations occupy open moorland; conifer plantations widely colonised.</td>
<td>Native but populations widely translocated or boosted by introductions.</td>
<td>Native but numbers have always been small in historic times; may have become extinct. Various reintroductions from Britain. Now restricted to a few small areas (none in N. Ireland).</td>
<td>Important sporting species in the Highlands (and source of venison). Upland populations often so numerous as to cause serious impact on vegetation, especially in preventing forest regeneration. Cause damage to vegetation in both planted and native woodlands unless numbers controlled. Numbers in most places depend on management by man.</td>
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<tr>
<td>Sika Deer</td>
<td>11,500</td>
<td>Scattered populations in various parts of England and S. Scotland; more extensive in Argyll and N. Highlands. Absent from islands.</td>
<td>Dense woodland, scrub, thicket stage of conifer plantations; less adaptable to tree-less areas than Red Deer.</td>
<td>Introduced in late 19th century, with some subsequent translocation. Some populations are stable or only slowly growing. Rapid expansion of range continuing in N. Scotland.</td>
<td>Introduced at same time as in Britain. Established in three main areas (one in N. Ireland).</td>
<td>Causes forestry damage. Shot for sport and as source of venison. Substantial hybridisation with Red Deer (population in Co. Wicklow fully hybridised).</td>
</tr>
<tr>
<td>Fallow Deer</td>
<td>100,000</td>
<td>Most of England, except NW and N. Wales; scattered populations elsewhere in mainland Britain. Absent from most islands but established on Mull.</td>
<td>Mature woodland; scarcer in coniferous forests. Forage on agricultural land near woods.</td>
<td>Introduced, probably by Normans (perhaps by Romans). Largely confined to parks until 17th century, after which escapes created wild populations, though numbers remained low until 20th century. Currently appears to be increasing slowly, if at all.</td>
<td>Similar to British. Found over much of central Ireland. Scattered populations in N. Ireland.</td>
<td>Causes damage to both trees and ground flora in forests and woodlands; also to agriculture culling produces venison.</td>
</tr>
<tr>
<td>Roe Deer</td>
<td>500,000</td>
<td>Widespread on Scottish mainlands (and some Inner Hebrides), N. England, S. and SW England, parts of East Anglia; scattered populations elsewhere.</td>
<td>Various woodland; agricultural areas if small woods available; open moorland in parts of Scotland.</td>
<td>Native but become extinct in England in 18th century and re-established by introduction. Still increasing in range in England.</td>
<td>Absent.</td>
<td>Causes forestry, agricultural and horticultural damage. Increasing interest in sporting and meat value.</td>
</tr>
<tr>
<td>Reeves’ Muntjac</td>
<td>40,000</td>
<td>Established over much of S. and Midland England; scattered populations to N. of main range and in Wales.</td>
<td>Dense habitats such as neglected coppice, unthinned plantations, scrub, plantations with ground cover.</td>
<td>Introduced via escapes from 1920s onwards; spread assisted by both deliberate accidental releases. Number and range increasing rapidly.</td>
<td>Absent.</td>
<td>Has dramatic impact on ground flora and shrubs in woods; increasingly recognised as a major conservation problem.</td>
</tr>
<tr>
<td>Chinese Water Deer</td>
<td>650</td>
<td>Population established in band from Bedfordshire/Hertfordshire to N. Norfolk.</td>
<td>Woodland and reed beds.</td>
<td>Introduced via escapes from parks during 20th century. Some populations eventually died out. Increase, if any, slow.</td>
<td>Absent.</td>
<td>Thought to pose little threat to forestry or agriculture.</td>
</tr>
<tr>
<td>Feral Goat</td>
<td>3,565+</td>
<td>Various mountains in England, Ireland, Scotland and Wales and many islands.</td>
<td>Mainly hills with cliffs, above 300m; may use woodland.</td>
<td>Introduced through escapes of domestic stock, which have been in Britain for c.4,500 years. No evidence of major changes in numbers.</td>
<td>Similar to British.</td>
<td>Goats cause devastating overgrazing in many parts of the world and do some damage to flora in British and Irish woodlands, but populations are generally small and limited in distribution; they are widely managed. Britain and Ireland hold more Feral Goats than any other W-European country except Crete (whose goats are very close to the wild ancestor, C. aegargus).</td>
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<tr>
<td>Feral Sheep</td>
<td>2,100</td>
<td>Soay sheep, from island of that name (St Kilda), now introduced to other offshore islands. Boreray sheep confined to island of that name (St Kilda).</td>
<td>Grassland.</td>
<td>Sheep introduced about 5,500 years ago. Soay is considered a primitive domestic breed, perhaps descended from the sort of sheep introduced by Neolithic people (though possibly introduced by the Vikings). Boreray sheep are a relatively modern breed. Both St Kilda populations fluctuate, with no long-term trends.</td>
<td>Apparently absent.</td>
<td>Of some scientific interest because subject of long-term study. Soay sheep of interest as a rare breed. These forms are endemic to Britain.</td>
</tr>
<tr>
<td>Red-necked Wallaby</td>
<td>50?</td>
<td>Inchconachan (Loch Lomond) and Isle of Man.</td>
<td>Scrub.</td>
<td>Introduced. Escapes and releases have established populations. One in the Weald survived 1940-1972. One in the Peak District, established 1940, is now reduced to two females (D.W. Yalden, pers. com.). Loch Lomond population now c. 30) deliberately established 1975. Escapes on Isle of Man (probably late 1960s) led to current population of c. 50 (Chris Sharpe, pers. comm.). No others survive.</td>
<td>Absent.</td>
<td>A pest of forestry in parts of Australia. Frequently liberated in Britain, since it is easy to keep in captivity, but has yet shown little propensity to increase. Individuals from Inchconachan have reached the mainland.</td>
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</table>
Table 1.1.3  Conservation assessment of species considered in this report. Single asterisks indicate that the species is included in the UK Steering Group’s Biodiversity long list (Anon. 1995) and double asterisks that this is in the short list of species of greater concern. (There are no mammals on the medium list). The conservation criteria are as used for that list (explained here on the next page)

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<tr>
<td>Mountain Hare*</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Squirrel**</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>5(b)</td>
</tr>
<tr>
<td>Grey Squirrel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Vole</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Field Vole</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Orkney Vole</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Water Vole**</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
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<td></td>
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<tr>
<td>Wood Mouse</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Harvest Mouse</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>House Mouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown Rat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship Rat</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Common Dormouse**</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>IVa</td>
<td></td>
<td></td>
<td>5(b)</td>
</tr>
<tr>
<td>Fat Dormouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Fox</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pine Marten*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>5(b)</td>
</tr>
<tr>
<td>Stoat*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weasel*</td>
<td>0</td>
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<td>1</td>
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</tr>
<tr>
<td>Polecat*</td>
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<td>0</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Feral Ferret</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Mink</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badger*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>(b)</td>
</tr>
<tr>
<td>Otter**</td>
<td>2?</td>
<td>0</td>
<td>-1</td>
<td>0</td>
<td>IIa IVa</td>
<td>II</td>
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<td>5(b)</td>
</tr>
<tr>
<td>Wildcat*</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>IVa</td>
<td>II</td>
<td>5(b)</td>
</tr>
<tr>
<td>Feral Cat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wild Swine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Deer*</td>
<td>0</td>
<td>1</td>
<td>-2</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sika Deer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fallow Deer*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roe Deer*</td>
<td>0</td>
<td>0</td>
<td>-2</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reeves’ Muntjac</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinese Water Deer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feral Goat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feral Sheep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red-necked Wallaby</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The following provides a key to interpret abbreviations used in Table I.1.3

**International Threat:**

2     Species of global conservation concern
2?    Status uncertain - possibly 2
1     Unfavourable conservation status in Europe
0     Favourable conservation status in Europe

**International importance:**

3     75+% of the world population in the UK
3*    Believed endemic
3??   Possible endemic
2     50-74% of the world population in the UK
1     25-49% of the world population in the UK
0     0-24% of the world population in the UK

**Decline:**

2     50-100% decline in numbers/range in GB in last 25 years
1     25-49% decline in numbers/range in GB in last 25 years
0     0-24% decline in numbers/range in GB in last 25 years
0     0-24% increase in numbers/range in GB in last 25 years
-1    25-49% increase in numbers/range in GB in last 25 years
-2    50+% increase in numbers/range in GB in last 25 years

**Localisation:**

2     Currently occurs in 1-5 10km squares in GB
1     Currently occurs in 6-15 10km squares in GB
+     Currently occurs in 16-100 10km squares in GB
0     Currently occurs in 101+ 10km squares in GB

EC Directives
Birds Directive Annex I (native species only)
EC Habitats Directive Annex II and/or IV (native species only)

Bern Convention Appendices I and II (native species only)

Bonn Convention Appendices I and II (native species only)

UK Act Sched. 1 Schedule 1} (a) Schedule 1
5 Schedule 5} Wildlife & Countryside (b) Schedule 5} Wildlife (Northern
8 Schedule 8} Act 1981 (c) Schedule 8} Ireland) Order 1985
5* Schedule 5 but protection against sale only
Table III.A.1.1 Summary of the numbers of BBS survey squares in which each of the principal 17 mammal species was reported to be present in each year of the trial mammal survey, 1995-1997.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Squares “Present” in Each Year</th>
<th>Percentages of Squares “Present” in Each Year (s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedgehog</td>
<td>26</td>
<td>138</td>
</tr>
<tr>
<td>Mole</td>
<td>95</td>
<td>284</td>
</tr>
<tr>
<td>Common Shrew</td>
<td>26</td>
<td>100</td>
</tr>
<tr>
<td>Rabbit</td>
<td>966</td>
<td>1117</td>
</tr>
<tr>
<td>Brown Hare</td>
<td>496</td>
<td>594</td>
</tr>
<tr>
<td>Mountain Hare</td>
<td>39</td>
<td>53</td>
</tr>
<tr>
<td>Red Squirrel</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Grey Squirrel</td>
<td>399</td>
<td>570</td>
</tr>
<tr>
<td>Brown Rat</td>
<td>23</td>
<td>78</td>
</tr>
<tr>
<td>Red Fox</td>
<td>423</td>
<td>527</td>
</tr>
<tr>
<td>Stoat</td>
<td>37</td>
<td>86</td>
</tr>
<tr>
<td>Weasel</td>
<td>19</td>
<td>69</td>
</tr>
<tr>
<td>Badger</td>
<td>82</td>
<td>152</td>
</tr>
<tr>
<td>Red Deer</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>Fallow Deer</td>
<td>47</td>
<td>57</td>
</tr>
<tr>
<td>Roe Deer</td>
<td>249</td>
<td>294</td>
</tr>
<tr>
<td>Reeves’ Muntjac</td>
<td>61</td>
<td>67</td>
</tr>
<tr>
<td>Total Squares</td>
<td>1334</td>
<td>1615</td>
</tr>
</tbody>
</table>
Table III.A.1.2 Results of likelihood-ratio tests of the significance of inter-annual differences in the proportion of survey squares in which species were recorded as present. The sample size N for the matched squares tests refers to the numbers of matched squares where changes in status occurred (see text for details).

<table>
<thead>
<tr>
<th>Species</th>
<th>Likelihood-ratio tests: $\chi^2$, $P$ (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedgehog</td>
<td>84.78, &lt;0.01</td>
</tr>
<tr>
<td>Mole</td>
<td>82.14, &lt;0.01</td>
</tr>
<tr>
<td>Common Shrew</td>
<td>35.49, &lt;0.01</td>
</tr>
<tr>
<td>Rabbit</td>
<td>4.83, &lt;0.1</td>
</tr>
<tr>
<td>Brown Hare</td>
<td>2.88, &lt;0.3</td>
</tr>
<tr>
<td>Mountain Hare</td>
<td>1.25, &lt;0.6</td>
</tr>
<tr>
<td>Red Squirrel</td>
<td>3.07, &lt;0.3</td>
</tr>
<tr>
<td>Grey Squirrel</td>
<td>9.92, &lt;0.01</td>
</tr>
<tr>
<td>Brown Rat</td>
<td>22.78, &lt;0.01</td>
</tr>
<tr>
<td>Red Fox</td>
<td>25.72, &lt;0.01</td>
</tr>
<tr>
<td>Stoat</td>
<td>12.80, &lt;0.01</td>
</tr>
<tr>
<td>Weasel</td>
<td>24.33, &lt;0.01</td>
</tr>
<tr>
<td>Badger</td>
<td>11.09, &lt;0.01</td>
</tr>
<tr>
<td>Red Deer</td>
<td>1.47, &lt;0.6</td>
</tr>
<tr>
<td>Fallow Deer</td>
<td>0.845, &lt;0.7</td>
</tr>
<tr>
<td>Roe Deer</td>
<td>5.17, &lt;0.1</td>
</tr>
<tr>
<td>Reeves’ Muntjac</td>
<td>0.546, &lt;0.8</td>
</tr>
</tbody>
</table>
Table III.A.1.3  Results of a simulation-based study of the power of a simple GLM to detect a range of gradual, long-term declines in presence/absence data. Each set of simulations consisted of 100 replicates, each based, as shown, on a sample size of 2000 BBS survey squares with declines in the “true” probability of detection of the model animal over a given period of years. The line of the table referring to a 25% decline over 25 years is shown in bold: this magnitude and rate of population change has been used as a key level for bird monitoring, and we suggest elsewhere that it could be extended to mammals.

<table>
<thead>
<tr>
<th>Number of Years</th>
<th>Average proportion of squares where presence is detected</th>
<th>Overall Decline</th>
<th>Percentage of replicates where a decline significant at a=0.05 was detected (likelihood-ratio test)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start of Decline</td>
<td>End of Decline</td>
<td>10%</td>
</tr>
<tr>
<td>10</td>
<td>0.3</td>
<td>0.27</td>
<td>10%</td>
</tr>
<tr>
<td>10</td>
<td>0.1</td>
<td>0.09</td>
<td>10%</td>
</tr>
<tr>
<td>10</td>
<td>0.03</td>
<td>0.027</td>
<td>10%</td>
</tr>
<tr>
<td>10</td>
<td>0.03</td>
<td>0.025</td>
<td>25%</td>
</tr>
<tr>
<td><strong>25</strong></td>
<td><strong>0.03</strong></td>
<td><strong>0.025</strong></td>
<td><strong>25%</strong></td>
</tr>
</tbody>
</table>
Table III.A.1.4 Mammals recorded on more than 1% of WBBS random stretches during the 1998 trial survey. Data on mammals were received from 93 of the 103 stretches surveyed. (Adapted from Marchant & Gregory 1999, Table 5).

<table>
<thead>
<tr>
<th>Species</th>
<th>Total animals counted</th>
<th>Number of occupied stretches</th>
<th>% Stretches occupied</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Counted in BBS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hedgehog</td>
<td>1</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Mole</td>
<td>10</td>
<td>37</td>
<td>40</td>
</tr>
<tr>
<td>Shrew spp.*</td>
<td>13</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Rabbit</td>
<td>1547</td>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td>Brown Hare</td>
<td>102</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Mountain Hare</td>
<td>42</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Red Squirrel</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Grey Squirrel</td>
<td>107</td>
<td>34</td>
<td>37</td>
</tr>
<tr>
<td>Brown Rat</td>
<td>3</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Red Fox</td>
<td>13</td>
<td>36</td>
<td>39</td>
</tr>
<tr>
<td>Stoat</td>
<td>1</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Weasel</td>
<td>1</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Badger</td>
<td>1</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>Red Deer</td>
<td>299</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Fallow Deer</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Roe Deer</td>
<td>23</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Reeves’ Munjac</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Not counted specifically in BBS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Vole</td>
<td>3</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>American Mink</td>
<td>3</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Otter</td>
<td>8</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

*Shrew species were not separated on the survey form.
Table VII.1.1 Summary of the potential contributions of the proposed monitoring schemes to the monitoring of each mammal species in the UK. “M” (for Main) indicates that a multi-species scheme is considered potentially to provide data central to the future monitoring of the species in question; “C” (for Combination) indicates that a combination of schemes will provide complementary and equally important information without any scheme necessarily being dominant; “A” (for Ancillary) indicates that a scheme will contribute supplementary information. Question marks indicate that a particular scheme may not be useful for the species shown, depending on species-specific factors such as the precise timing of survey visits (see species accounts). Multi-species schemes are referred to as follows: Breeding Bird Survey (BBS); National Game Bag Census (NGBC); Winter (visual) Transect Survey (WTS); Sign Transect Survey (STS); Mammals on Roads (MOR); Mammals on Nature Reserves (MONR); Garden Mammal Watch (GMW); Owl Pellets Scheme (OP).

<table>
<thead>
<tr>
<th>Species</th>
<th>Multi-species schemes</th>
<th>Single species scheme</th>
<th>Role</th>
<th>Suggested Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedgehog</td>
<td>BBS: C</td>
<td></td>
<td>C</td>
<td>Monitoring techniques need development: live-trapping or faecal signs.</td>
</tr>
<tr>
<td>Mole</td>
<td>NGB: C</td>
<td>WTS: C?</td>
<td>STS: C</td>
<td></td>
</tr>
<tr>
<td>Lesser White-toothed Shrew</td>
<td>STS: C</td>
<td>MOR: C</td>
<td>MONR: C</td>
<td></td>
</tr>
<tr>
<td>Common Shrew</td>
<td>GMW: C</td>
<td>OP: C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pygmy Shrew</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Shrew</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabbit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown Hare</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain Hare</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Squirrel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey Squirrel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Vole</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Species</th>
<th>Multi-species schemes</th>
<th>Single species scheme</th>
<th>Role</th>
<th>Suggested Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Vole</td>
<td>A</td>
<td>M</td>
<td>Live-trapping/capture-mark-recapture with other small mammals, but needs development and piloting.</td>
<td></td>
</tr>
<tr>
<td>Orkney Vole</td>
<td>M</td>
<td></td>
<td>Live-trapping/capture-mark-recapture.</td>
<td></td>
</tr>
<tr>
<td>Water Vole</td>
<td>A</td>
<td>M</td>
<td>Transect field sign searches within the grid used in previous surveys.</td>
<td></td>
</tr>
<tr>
<td>Wood Mouse</td>
<td>A</td>
<td>M</td>
<td>Live-trapping/capture-mark-recapture with other small mammals, but needs development and piloting.</td>
<td></td>
</tr>
<tr>
<td>Yellow-necked Mouse</td>
<td>M</td>
<td></td>
<td>Live-trapping/capture-mark-recapture in woods; techniques for other habitats need development.</td>
<td></td>
</tr>
<tr>
<td>Harvest Mouse</td>
<td>A</td>
<td>M</td>
<td>Standardised hair-tube surveys and nest searches.</td>
<td></td>
</tr>
<tr>
<td>House Mouse</td>
<td>A</td>
<td>M</td>
<td>Improvement of pest control records.</td>
<td></td>
</tr>
<tr>
<td>Brown Rat</td>
<td>C</td>
<td>C</td>
<td>Improvement of pest control records.</td>
<td></td>
</tr>
<tr>
<td>Ship Rat</td>
<td>M</td>
<td></td>
<td>Methods for island populations need development, use questionnaires for mainland populations.</td>
<td></td>
</tr>
<tr>
<td>Common Dormouse</td>
<td>A</td>
<td>M</td>
<td>National Dormouse Monitoring Scheme, perhaps expanded.</td>
<td></td>
</tr>
<tr>
<td>Fat Dormouse</td>
<td>M</td>
<td></td>
<td>Extension of present annual monitoring, formalised, to more sites; use of DETR licence returns.</td>
<td></td>
</tr>
<tr>
<td>Red Fox</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>Pine Marten</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Stoat</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Weasel</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Species</td>
<td>Multi-species schemes</td>
<td>Single species scheme</td>
<td>Role</td>
<td>Suggested Approach</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------</td>
<td>-----------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Feral Ferret</td>
<td>C C C C C C</td>
<td>A</td>
<td>Collate distribution data from other schemes as they are reported.</td>
<td></td>
</tr>
<tr>
<td>American Mink</td>
<td>A A</td>
<td>M</td>
<td>Collect abundance and distribution data through Otter and Water Vole monitoring.</td>
<td></td>
</tr>
<tr>
<td>Badger</td>
<td>A A A A A</td>
<td>M</td>
<td>Repeats of the National Badger Survey.</td>
<td></td>
</tr>
<tr>
<td>Otter</td>
<td>A A</td>
<td>M</td>
<td>Repeats of previous Otter surveys, extending monitoring to coastal populations.</td>
<td></td>
</tr>
<tr>
<td>Wildcat</td>
<td>A A</td>
<td>M</td>
<td>Questionnaire surveys and roadkill collection, periodical scat surveys, genetic monitoring.</td>
<td></td>
</tr>
<tr>
<td>Red Deer</td>
<td>A A A A A A</td>
<td>C</td>
<td>Ongoing monitoring in certain habitats/regions, possibly new direct count surveys elsewhere.</td>
<td></td>
</tr>
<tr>
<td>Sika Deer</td>
<td>A A A A</td>
<td>C</td>
<td>Ongoing monitoring in Scotland.</td>
<td></td>
</tr>
<tr>
<td>Fallow Deer</td>
<td>A A A A A A</td>
<td>C</td>
<td>Ongoing monitoring in certain habitats/regions, possibly new pellet count/transect surveys elsewhere.</td>
<td></td>
</tr>
<tr>
<td>Roe Deer</td>
<td>A A A A A A</td>
<td>C</td>
<td>Ongoing monitoring in certain habitats/regions, possibly new direct/pellet count/transect surveys elsewhere.</td>
<td></td>
</tr>
<tr>
<td>Reeves’ Muntjac</td>
<td>A A A A A A</td>
<td>C</td>
<td>Ongoing monitoring in certain habitats/regions, possibly new direct/pellet count/transect surveys elsewhere.</td>
<td></td>
</tr>
<tr>
<td>Chinese Water Deer</td>
<td>A A A A</td>
<td>C</td>
<td>Maintain and formalise current monitoring.</td>
<td></td>
</tr>
<tr>
<td>Feral Goat</td>
<td></td>
<td>M</td>
<td>Collate existing count data.</td>
<td></td>
</tr>
<tr>
<td>Feral Sheep</td>
<td></td>
<td>M</td>
<td>Monitor areas of possible expansion.</td>
<td></td>
</tr>
<tr>
<td>Red-necked Wallaby</td>
<td></td>
<td>M</td>
<td>Unestablished aliens scheme.</td>
<td></td>
</tr>
</tbody>
</table>
Figure I.1.1  How monitoring supports management by helping to answer key questions
**Figure II.3.2 Various sampling designs**
The squares represent potential sample sites (horizontal axis) in different years (vertical axis); filled squares show sites sampled in each year.

A. Independent sampling in each year.  
Some sites are sampled in more than one year, but only by chance.

B. Constant sampling sites.  
The original random sample is maintained indefinitely.
C. Sampling with partial replacement.
In this particular case, one of the three sites drops out each year, being replaced with another site at random; each site stays in the sample for three years; it may re-enter the sample but only by chance.

![Sample Sites](image)

**Figure II.3.3 Rotation Sampling**
The squares represent potential sample sites (horizontal axis) in different years (vertical axis); filled squares show sites sampled in each year.

A. Simple rotation.
Each site remains in the sample for a single occasion. In this particular case, because one in three of the sites is sampled on each occasion, each site re-enters the sample after a gap of two occasions; each sampling cycle (during which every site is sampled once) is thus three occasions long.

B. More complex rotation.
East site remains in the sample for more than a single occasion. In this particular case, sites remain in the sample for three occasions but then drop out for six; each sampling cycle is nine occasions long.
Figure III.A.1.1. Distribution of records of presence in BBS squares for Rabbit in 1997. Each circle represents a BBS square from which mammal records were returned: closed circles indicate where Rabbits were recorded.
Figure III.A.1.2  Distribution of records of presence in BBS squares for Brown Hare in 1997. Each circle represents a BBS square from which mammal records were returned: closed circles indicate where Brown Hares were recorded.
Figure III.A.1.3  Distribution of records of presence in BBS squares for Reeves’ Muntjac in 1995. Each circle represents a BBS square from which mammal records were returned: Closed circles indicate where Reeves’ Muntjac were recorded.
Figure III.A.1.4  Distribution of records of presence in BBS squares for Red Squirrel over all years 1995-1997. Each circle represents a BBS square from which mammal records were returned: closed circles indicate where Red squirrels were recorded.
Figure III.A.1.5  Sample sizes required for the detection of a 10% decline from a starting proportion $p^1$ at $\alpha = 0.05$

![Sample sizes required for the detection of a 10% decline from a starting proportion $p^1$ at $\alpha = 0.05$.](image)

Figure III.A.1.6  Sample sizes required for the detection of a 20% decline from a starting proportion $p^1$ at $\alpha = 0.05$

![Sample sizes required for the detection of a 20% decline from a starting proportion $p^1$ at $\alpha = 0.05$.](image)
Figure III.A.1.7  Sample sizes required for the detection of a 30% decline from a starting proportion \( p^1 \) at \( \alpha = 0.05 \).
APPENDICES

Appendix 1  Breeding Bird Survey Forms
Appendix 2  Garden BirdWatch forms