This document should be cited as:
Crick,HQP, Baillie,SR & Percival,SM 1990
A review of raptor population monitoring
NCC Chief Scientist Directorate
commissioned research report no 1011

A REVIEW OF RAPTOR POPULATION MONITORING

by

H.Q.P. CRICK, S.R. BAILLIE
& S.M. PERCIVAL

A study commissioned by the
Nature Conservancy Council to investigate the requirements for a scheme to monitor the population sizes and breeding success of raptors in the U.K.
(NCC's Nominated Officer: M.W. Pienkowski)

BTO Research Report no. 49
July 1990

The British Trust for Ornithology
Beech Grove, Station Road
Tring, Herts HP23 5NR
England

Crick, H.Q.P., Baillie, S.R.& Percival, S.M., 1990.
A review of raptor population monitoring. Tring (BTO).

Published in July 1990 by the British Trust for Ornithology, Beech Grove, Tring, Hertfordshire, UK, with financial assistance from the Nature Conservancy Council.

ISBN 0-903793-05-9

CONTRACT REPORTS

Project number: Bi8

Report number: 1011

File number: S5-04-03

Contract number: HF3/03/192

Date received: September 1989 in draft; May 1990

Report title: A review of population monitoring of birds of prey (by H Q P Crick, S R Baillie & S Percival)

Contract title: Services in ornithology

Contractor: British Trust for Ornithology

Comments: see following pages

Restrictions: None

Number of copies received: 50

Distribution:
Library Headquarters, Peterborough (2 copies)
Nominated Officer: Dr M W Pienkowski (1 + spares)
Chief Scientist
Head Ornithology Branch (via MWP)
CSD Set
CHQ Field Unit Leaders (1 each)
Dr J Hellawell
Mr M Felton
Dr L A Batten/M J Nugent
P Clement
D A Stroud
Dr C A Galbraith
Dr E M Bignal
Dr G P Mudge
Other Ornithology Branch staff, on circulation
ACB Chairman
ACOS secretariat
EGI Library
SOC Library
Dr C J Bibby, RSPB (via MWP)
Mr R Porter, RSPB (via MWP)

cc Karen Mossman - for the CSD file
Ornithology day-book
Report circ list file

REVIEW OF MONITORING OF BIRDS OF PREY

Britain supports internationally important populations of several species of birds of prey. The vulnerability of these birds is recognised both in domestic and EEC legislation, and NCC needs to monitor the populations and their performance. As for some other statutory duties, the work required for effective implementation is possible only by collaboration between NCC, large numbers of volunteers and their organisations, together with additional resources.

The previous history of raptor populations and pesticides demonstrates also the wider value of monitoring such top predators as early warning systems for major environmental problems. Studies, for example on golden eagles (A J Watson, NCC) and merlins (C J Bibby, RSPB), indicate also a role as indicators of land-use change. Work developed by C A Galbraith (NCC, in conjunction with Raptor Groups) has also demonstrated the use of such information in positive land-use planning. Because of the low density at which these birds occur, they are not generally monitored by the same methods and projects as other bird species. Some especially rare species (eg white-tailed sea-eagle, red kite, osprey) are covered by existing work. There are also several active workers and notably raptor groups (some partly supported by NCC) monitoring the more common species. However, this work needs reviewing and a national system developed, with appropriate coordination, reporting and feedback to participants.

The study reported here is the first of two reports on a review with the following objectives.

"1. To review the needs for monitoring of population sizes and performance of raptors, including sparrowhawk, buzzard, golden eagle, hen harrier, peregrine, hobby, merlin, kestrel, and owls. The review should consider sampling options for species with fixed "traditional" nesting places (eg eagle, peregrine, sparrowhawk, tawny owl), and for those probably more mobile (eg hen harrier, short-eared owl). The report may also suggest options which balance requirements and resource needs.

"2. To assess the methods for monitoring population size, breeding performance and, if practicable, survival rates.

"3. To consider the sample sizes required, paying particular attention to the geographical distribution and grouping of observations. Dr C A Galbraith (NCC Peterborough) should be consulted to attempt to make geographical units as compatible as possible with other ornithological work. Flexibility in any sampling system should also be considered, in view of the tendency for voluntary workers to select their preferred pairs. Checks for the system to counter this should be indicated.

"4. To recommend a means of achieving the necessary coverage, using low-cost methods, eg contributions towards expenses of raptor groups and individuals, similar contributions to professional workers undertaking related studies, incorporation in wardens' work programmes, etc. Full account should be taken of existing studies; the possibilities for utilising the results of these in an overall scheme; and any needs for modifications to these projects. A variety of options should be indicated, with approximate costings. Recommendations should be made also with regard to standard recording forms and instructions, and security systems for sensitive information.

"5. The reviewer should consult raptor workers throughout the country and, throughout the work, consult NCC's Nominated Officer."

Although the final report of this work will be produced jointly with NCC, views expressed in the current report are those of the contractor, and not necessarily those of NCC or its officers.

The present report will be used as a basis for further discussions with interested parties, while further necessary aspects of the review are undertaken in parallel.

Dr M W Pienkowski
Assistant Chief Scientist (Terrestrial Sciences)
Nature Conservancy Council

CONTENTS

GENERAL SUMMARY

1) There is an important need for the monitoring of breeding populations of British raptors for conservation and environmental monitoring reasons including: (a) the conservation of several populations of international importance; (b) the sensitivity of raptors as bio-indicators of environmental changes and pollution; (c) the continued illegal persecution and taking of raptors from the wild; and (d) the concern of the general public for the fate of these attractive species. This report outlines the requirements and options for a National Raptor Monitoring Scheme (NRMS).

2) The aims of a NRMS should be to monitor distributions, population sizes, breeding success and survival of raptors in an efficient low cost manner by encouraging the contribution of amateur raptor specialists and other ornithologists.

3) The species to be covered in this report are, with one exception, all those not covered by the Rare Breeding Birds Panel i.e.: Hen Harrier, Sparrowhawk, Buzzard, Golden Eagle, Kestrel, Merlin, Hobby, Peregrine, Barn Owl, Long-eared Owl, Short-eared Owl, Little Owl, Tawny Owl and possibly the Raven.

4) Methodologies for censusing raptors and for measuring their breeding and survival rates are reviewed. A range of potential biases could affect these studies, but they can be controlled adequately within carefully designed studies. Data collection and analysis should be carefully stratified according to region, land-type and habitat, etc. and must take into account the strong effects that small mammal population cycles can exert on some raptor populations.

5) Major organisations that co-ordinate raptor fieldwork and undertake specialist projects in Britain are: the British Trust for Ornithology, Royal Society for the Protection of Birds and the Nature Conservancy Council. Specialist projects are also undertaken in the Institute of Terrestrial Ecology, in Universities and by the Forestry Commission. Groups of amateurs are coordinated in Scotland by amateur-led Raptor Study Groups, some of which have received support in terms of staff-time and finance from NCC and RSPB.

6) Breeding biology, suitable census and nesting study techniques and current levels of fieldwork are reviewed briefly for each species. For most species, a combination of intensive and extensive surveys and studies can be employed; although some species (eg: Sparrowhawk and Hobby) are considered to be very difficult to study except through very intensive fieldwork by specialist ornithologists (amateur or professional).

7) It is concluded that a NRMS is feasible because much information on raptors is collected annually in Britain and

organisations exist that could mobilise their members to undertake the extra fieldwork required to fill information gaps. There is already a good degree of collaboration within ornithological organisations in Britain and this could be readily developed further within the field of raptor monitoring.

RECOMMENDATIONS

1) A National Raptor Monitoring Scheme (NRMS) should be developed to provide important information for conservation and environmental monitoring reasons.

2) A NRMS should seek to monitor distributions, population sizes, breeding success and survival of raptors in an efficient low cost manner by encouraging the contribution of amateur raptor specialists and other ornithologists.

3) A NRMS should seek to build on the high degree of collaboration and cooperation that already exists between the major organisations that coordinate raptor fieldwork or undertake specialist raptor projects in the country, ie: the British Trust for Ornithology, Royal Society for the Protection of Birds, Nature Conservancy Council, Institute of Terrestrial Ecology, the Universities, Forestry Commission, Hawk and Owl Trust (Hawk Trust) and the amateur-led Raptor Study Groups.

4) The raptors that should be covered by a NRMS are those not already monitored by specialists in NCC and RSPB or by the Rare Breeding Birds Panel. Therefore a NRMS should cover: Hen Harrier, Sparrowhawk, Buzzard, Golden Eagle, Kestrel, Merlin, Hobby, Peregrine, Barn Owl, Long-eared Owl, Short-eared Owl, Little Owl and Tawny Owl. The Raven could be included too, for logistic and conservation reasons, because it occurs at similar locations and nest sites as Golden Eagle, Buzzard and Peregrine, it is a carrion-eater and is affected by many of the same factors that affect other carrion-eaters, and it is apparently in decline in some parts of its range.

5) Census methods to assess distributions and relative abundances of raptors must be carefully designed to control for the effects of the potential biases discussed in section 2 of this report. The census methods most appropriate for each species are given below:

Hen Harrier	Transect survey, timed counts, intensive nest searches
Sparrowhawk	Intensive nest searches (very difficult species to survey)
Buzzard	Transect survey, timed counts
Golden Eagle	Occupation rates of traditional nest sites, intensive nest searches
Kestrel	Transects by car along roads (in open country), timed counts, occupation rates of nestboxes where natural sites are rare
Merlin	Intensive nest searches (difficult species to survey)

Hobby	Intensive nest searches (very difficult species to survey)
Peregrine	Occupation rates of traditional sites, intensive nest searches
Barn Owl	Intensive nest searches (very difficult species to survey)
Long-eared Owl	Point counts (with playback), occupation rates of nestboxes where natural sites are rare
Short-eared Owl	Transect surveys, timed counts, intensive nest searches
Little Owl	Transect surveys, point counts (with or without call playback), timed counts
Tawny Owl	Point counts (with or without call playback) territory mapping, occupation rates of nestboxes where natural sites are rare
Raven	Intensive nest searches

6) i) The breeding success of raptor populations should be monitored every year at a set of "annually checked sites", stratified according to region, habitat, etc., to provide a constant baseline for comparison with data gathered from sites visited less frequently.

ii) It is particularly important that observations should begin early in the season to include pairs that fail early and move out of an area.

iii) Records should be collected of:
- a) No. of territories or ranges checked,
- b) No. of ranges occupied before laying,
- c) No. of ranges in which eggs are laid,
- d) No. of ranges in which fledglings are produced,
- e) No. of eggs in each nest; and laying date,
- f) Hatching success in each nest,
- g) No. of nestlings in each nest, (preferably at early and late stages),
- h) Fledging success from each nest.

iv) Measures of (e-h) above should be calculated for all potential pairs, laying pairs and successful pairs. The value (h/b) (i.e.: no. fledglings per occupied range), is important for estimating the overall production of species for conservation purposes, but it is one of the most difficult measures to obtain, ((b) is especially difficult to obtain for species without traditional nest sites). If (h/b) cannot be measured, then other measures such as (h/c) should be used to provide useful indications of how well the birds in a population have reproduced in any year.

v) Moderately increased rates of visiting to nests should be encouraged so that egg and nestling survival rates could be calculated. Measurements of eggs and nestlings should be encouraged to allow accurate ageing and sexing of nest contents.

vi) A standardised "site record form" should be introduced for recording site and visit details for raptor nests whether or not they have been used. The BTO Nest Record Card would be most suitable for this purpose. Disturbance at the nests of protected species should produce information of real value for conservation purposes. It is strongly recommended that a detailed record of nest visiting should be submitted to the NCC instead of the general summary currently returned each year by Schedule 1 licence holders.

vii) Increased effort should be encouraged toward the recording of greater numbers of nest records for Buzzard, Hobby, Short-eared Owl, Long-eared Owl and Raven.

7) i) The ringing of raptors should continue to be encouraged to enable survival rates to be monitored. In particular, ringing of adult raptors should be promoted because analyses consisting solely of recovery rates of ringed pulli are prone to serious statistical difficulties. (Currently the majority of raptors ringed are at the pullus stage).

ii) Full rebates (currently funded by NCC) on raptor rings should be continued, to encourage ringing.

iii) Although recovery information is fully computerised at the BTO, ringing data should also be input to facilitate survival analyses, and analyses of brood sizes for nests not reported on Nest Record Cards.

8) Environmental data should be recorded by observers that contribute data to a NRMS (especially weather, habitat and land-type) so that these factors can be used to help explain variations in breeding numbers, reproductive performance and survival of raptors.

9) Concurrent with the development of a NRMS it is important to encourage the development of and collaboration with systematic small mammal trapping surveys, such as those currently organised by the Mammal Society and Ministry of Agriculture Fisheries and Food. Small mammal populations fluctuate widely over periods of 3-4 years and they have important effects on numbers, reproduction and survival of Kestrel, Barn Owl, Tawny Owl, Short-eared Owl, Long-eared Owl and possibly on Hen Harrier and Buzzard. Correlation with data from small mammal trapping surveys will be essential in helping to explain variations in the demographic parameters of raptors that are dependent upon them.

10) Central coordination is required to ensure

(a) Standardised recording techniques;

(b) adequate sampling of data in each land-tupe, habitat type and region.

(c) development of Raptor Study Groups in England and Wales (Scotland is largely covered).

(d) develop efficient feedback to contributors of information, analyses and techniques

(e) efficient data gathering, storage, analysis and dissemination.

11) Funding is required for:

(a) full-time scientific organiser for negotiating collaboration, developing fieldwork and analytical methodology, data analysis and publication of results, and to organise newsletters and meetings;

(b) clerical staff to administer scheme and input data to the computer.

(c) materials, postage etc, for NRMS and to contribute to administration costs of raptor study groups. (Travel money may not be an advisable contribution to amateurs, except as one-off special payments, because it would form a potentially open-ended commitment that could arouse ill-will if discontinued at a later stage).

(d) full rebates on rings used on raptors.

(e) support for the administration and trap costs for a core set of amateur-run small mammal population surveys (perhaps to be coordinated by the Mammal Society), stratified by region, habitat and land-use.

1. INTRODUCTION

1.1 Why monitor raptors?

There are a number of pressing reasons why it is important to establish a scheme to monitor the population sizes and productivities of raptors in the UK.

1. The UK has a special responsibility for the conservation of several raptor populations of international importance. In western Europe, outside the USSR, the UK holds more than 10% of breeding Peregrines, Golden Eagles and Hen Harriers. In the European Community, the UK holds nearly all the breeding Merlins, 70% of Ospreys and 67% of White-tailed Eagles (Cadbury 1988).

2. Raptors have proved to be sensitive bio-indicators of environmental changes and pollution. They occur at the top of food chains and are vulnerable to any breaks that might occur within a chain. Thus by monitoring populations of raptors, it is possible to monitor the functioning of the ecosystems upon which those birds depend. Examples of such work have shown how changes in land use have adversely affected Golden Eagles in Scotland (Watson et al. 1987), Merlins in the Peak District (Haworth & Fielding 1988) and the ecosystems of which they form part.

   Raptors are not only more sensitive to the effects of certain pollutants in comparison with other animals, but they are also vulnerable to the processes of bioconcentration and 1bioaccumulation (Brown 1974). This vulnerability was revealed in the UK when raptor populations severely declined in the late 1950s and early 1960s (Newton 1979). Agricultural pollution from organochlorine pesticides accumulated in the fat stores of animals and were concentrated at higher levels within food chains. Not only did raptors accumulate the highest concentrations of the toxic metabolites of DDT and dieldrin (among other pesticides), but raptors were also a hundred times more sensitive to the toxic effects than songbirds (Newton 1988).

   Although these organochlorine pesticides are now banned or have had their uses restricted in the U.K., raptors have the capacity to be useful bioindicators of industrial and agricultural pollutants in the future. The position of raptors at the top of food chains makes them vulnerable to the adverse effects of pollutants at any point within those food chains. If ecosystem function is disrupted, even at the level of soil processes, then it is quite likely that raptors will be affected. Raptors are important, therefore, as bioindicators of the "health" of whole ecosystems upon which both wildlife and people depend. The discoveries of pollutant accumulation and their side-effects in raptors have alerted health authorities to be aware of the potential risks of raised levels of pollutant burdens in human tissues, particularly in human breast milk.

3. Persecution of raptors by man is a continuing problem despite legal protection under the Wildlife and Countryside Act, 1981. Shooting, poisoning and lethal trapping occur at rates which cause concern. This persecution is perpetrated in the interests of gamekeeping and upland sheep rearing (Cadbury 1988). Raptors are also frequent victims of the illegal use of poison baits to control foxes and crows (Cadbury et al. 1988). It is believed that such persecution has significant effects on the distributions of raptors, for example: the lack of colonisation of the Midlands and eastern England by Buzzards and the recent population decline shown by Hen Harriers in the southern part of its range (Cadbury 1988). Egg-collecting and the taking of young for falconry is still a serious problem for some species, and has the potential to limit the distributions of raptors. Careful monitoring is required to assess the significance of such interference and the effectiveness of current protection schemes.

4. Raptors have a high public profile. The general public is concerned about the fate of these species because of their unusual life-style, rarity and aesthetic appeal.

The Nature Conservancy Council carries out important statutory requirements with respect to raptors under:

(a) The European Communities Council Directive of April 1979 on the Conservation of Wild Birds. Article 4.1 of the Directive lists rare or vulnerable species which require special measures for their conservation, including: Honey Buzzard, Red Kite, White-tailed Eagle, Marsh Harrier, Hen Harrier, Montagu's Harrier, Golden Eagle, Osprey, Merlin, Peregrine, Snowy Owl and Short-eared Owl. Article 4.2 requires the conservation of the habitat of regularly occurring migratory species, including Hobby (NCC 1988).

(b) The Nature Conservancy Council Act 1973. This states that the NCC should undertake monitoring of species of conservation interest in the UK. This includes raptors for the reasons outlined above, but such monitoring is severely hampered by current lack of funds.

(c) The Wildlife and Countryside Act 1981. The NCC are required to licence the disturbance of birds listed on Schedule 1 (including several raptors) and to advise government on the conservation needs of wildlife, including raptors, in the U.K.

It is impracticable for NCC to fulfil all its duties without the participation of large numbers of skilled amateurs and their coordinating societies. In practice, additional funding from other sources is required if monitoring is to be undertaken to the level needed to provide the answers that both conservationists and the general public require.

1.2 Aims of the review

Much work on raptors being undertaken in the UK is by a large body of amateurs and a few professional ornithologists. Some of these workers have joined together to form Raptor Study Groups (most notably in Scotland), but these groups and individuals work autonomously and independently using their own methods for their own interests. There is a lack of standardisation in methods and recording, and little co-ordination or collation of results, except in Scotland. A nationally coordinated recording scheme would allow comparison between regions and habitats and provide an early-warning system for raptor (and other aspects of) conservation throughout the whole country.

The aims of this review are as follows:

1. To review census methods suitable for measuring the population size and distribution of breeding raptors.

2. To review methods for measuring the breeding success of raptors.

3. To review briefly methods for estimating the survival rates of raptors.

4. To describe the current extent of raptor research in the country: who is doing what, and where they are doing it.

5. To give a brief species-by-species account of (a) current numbers and distribution, (b) the proportion of the population already being studied, and (c) suitable monitoring methods given each species' breeding biology.

6. To outline the options for a national monitoring scheme with the requirements of (a) allowing regional monitoring when possible; (b) low cost; (c) encouraging the contribution of data by amateurs and professionals; (d) cooperation between interested bodies; and (e) provision of feedback of information to contributors.

A National Raptor Monitoring Scheme (NRMS) should provide information at national and regional levels on:

(i) Changes in breeding distributions;
(ii) Changes in breeding population sizes;
(iii) Changes in breeding success;
(iv) Changes in survival rates

Population dynamics models should be developed to predict the effects of changes in population parameters and provide an early warning system for remedial action.

The non-breeding, non-territorial segments of raptor populations are impossible to census because these birds cannot be assigned to any home range with certainty and generally show a greater and more variable use of space than breeding birds. The scheme should not be concerned with measuring pesticide and

pollutant residue levels in raptors because this is already covered by the NCC currently contracted to the Institute of Terrestrial Ecology (Monks Wood) (ITE)) and by the Wildlife Incident Scheme of the Ministry of Agriculture, Fisheries and Food (MAFF), and the Department of Agriculture and Fisheries for Scotland (DAFS). There should be no difficulty in exchanging information between a NRMS and ITE if both are under contract to the NCC, but close links should be developed with MAFF and DAFS to ensure that data on pollutant residues can be compared with population monitoring data.

Although a NRMS will accrue substantial quantities of information about raptors in Britain, it is not anticipated that NRMS databases will be able to provide site-specific information of use for site-protection purposes. In many cases, particularly for rare or threatened species, raptor fieldworkers will not be willing to give site-location information to a NRMS. Indeed, a NRMS has little need of such detailed information for monitoring purposes, and it would be counter-productive to try to force fieldworkers to reveal locations. However, a NRMS would become a source of information about who could provide such information. At a more general level, a NRMS will be able to calculate raptor densities within the study areas of its participants (subject to their approval), as well as to extrapolate from local information to give estimates of raptor densities over wider geographical units.

A second study by the BTO, to follow the present one, will provide further detailed information for the development of the NRMS. The study will use Nest Record Card and Ringing data (a) to examine sampling strategies; (b) to undertake sensitivity analyses and (c) to consider the geographical units for practical measurements of breeding success and survival. The analyses will also provide baseline information on historical changes in breeding success and survival.

1.3 Which species?

A National Raptor Monitoring Scheme should cover all species of diurnal and nocturnal raptors in Britain. However, some species with small breeding populations are already monitored to a very high level of accuracy by the Rare Breeding Birds Panel (Spencer et al. 1988) or by special projects, such as the NCC/RSPB Sea Eagle and Red Kite projects. Of the species treated by the RBBP, the Hobby is little studied and probably more widely distributed than is currently known and has been included in this review. Also included is the non-raptorial Raven, because of concern over apparent declines in population in parts of its range and because it occurs in similar locations and has similar feeding requirements to some raptors.

The species to be considered for inclusion in this review and those already covered by the RBBP are given in Table 1. The Tawny Owl and Barn Owl have been studied by S.M.P. over the past three years. His forthcoming report will yield information that can be used to provide recommendations for the NRMS for these species. To

avoid duplication of effort, these two species are considered only briefly in this review. The final report from the three year study was completed in March 1990 (Percival 1990).

Table 1: Raptor species to be monitored by a U.K. National Raptor Monitoring Scheme (NRMS) and by the Rare Breeding Birds Panel (RBBP)

NRMS	RBBP
*Hen Harrier Circus cyaneus	*Honey Buzzard Pernis apivoris
Sparrowhawk Accipiter nisus	*Red Kite Milvus milvus
Buzzard Buteo buteo	*White-tailed Eagle Haliaeetus albicilla
*Golden Eagle Aquila chrysaetos	*Marsh Harrier Circus aeruginosus
Kestrel Falco tinnunculus	*Montagu's Harrier Circus pygargus
*Merlin Falco columbarius	*Goshawk Accipiter gentilis
+*Hobby Falco subbuteo	*Osprey Pandion haliaetus
+*Peregrine Falco peregrinus	*Snowy Owl Nyxtea scandiaca
*Barn Owl Tyto alba	
Long-eared Owl Asio otus	
Short-eared Owl Asio flammeus	
Little Owl Athene noctua	
Tawny Owl Strix aluco	
Raven Corvus corax	

* Protected species under Schedule 1 of the 1981 Wildlife and Countryside Act.
+ Also covered by RBBP.

2. CENSUS METHODS

Census methodology for studying raptor populations is a rather neglected area compared with that for song birds or shorebirds. Raptors are difficult to census accurately because (a) they occur at relatively low densities; (b) individuals are often widely-ranging and overlap their ranges with other individuals and (c) individuals can move rapidly over wide areas.

The suitability of a census method for a species depends on the breeding biology, behaviour and ecology of that species. In the context of a National Raptor Monitoring Scheme, a census should provide answers to the following questions:

1. What is the distribution of the breeding population and is it changing?

2. What is the density of the breeding population each year? What is its normal range of variation and does it exhibit regular population cycles? Does it show any long-term trends? How does it vary with habitat and region?

3. What is the absolute size of national and regional populations and are they changing?

The methodology for censusing breeding raptors has been reviewed in detail by Fuller & Mosher (1981, 1987) and general reviews of bird census methodology have been made by Dawson (1985) and Verner (1985). The five main types of breeding raptor census that are relevant to the UK are: (i) transect surveys, (ii) point counts, (iii) timed counts, (iv) nest site surveys and (v) territory mapping.

2.1 Transect surveys, point counts and timed counts

Transect surveys and point counts are suitable for measuring distributions and relative abundances of raptors. They allow large areas to be covered and can be undertaken by a large body of observers who individually do not have to commit a large amount of time to the surveys.

In transect surveys, observers travel along known and recorded routes, at fixed speeds, and record the numbers and activities of raptors. "Strip transects" restrict records to within a strip on either side of the transect line; strip width depends on factors affecting the detectability of birds. "Variable distance line transects" involve the collection of distances and angles to all birds detected; the results require special analysis to calculate population densities (Burnham *et al.* 1980).

Point counts involve stops of fixed duration at regular intervals along transect lines or at points positioned according to the sampling technique employed (for example: random, lattice, random-stratified according to habitat) (Reynolds *et al.* 1980, Buckland 1987). A modification of point counts involves

broadcasting tape-recorded bird calls to elicit responses from hidden raptors (especially effective for owls) (Fuller & Mosher 1987, Sara & Zanca 1989).

Travel along transects or between points can be undertaken by foot or car. A very important requirement of all such surveys is strict standardisation of methods and recording, especially for time spent and distance travelled while in the field. Zero or null records are also important.

A less rigorous technique than transects or point counts, but one that can provide reasonable estimates of relative abundance and distribution, is that of "timed counts". It was used in the BTO Winter Atlas Survey (Lack 1986) and could provide useful information on some breeding raptor populations. Observers record the time spent in the field and record how many birds of each species were seen during each observation period. Numbers of birds recorded usually increases with time spent in the field, so each count should be corrected to a standard duration. The correction factor is calculated from a regression of count size on duration. When the slope of such a regression is not significantly different from zero, then no correction is necessary. Such an occurrence might occur when a large proportion of a timed count is spent in unsuitable habitat or when a species occurs so infrequently during the normal course of a count that zero counts are often recorded. In the Winter Atlas, counts of Sparrowhawk, Buzzard and Kestrel required correction, but Hen Harrier, Golden Eagle, Merlin and Peregrine did not (Lack 1986).

Timed counts often suffer from a lack of control over how observers carry out their fieldwork, for example: time of day, length of time in a plot, mode of transport (foot, bicycle, car), and the proportion of time spent in any one habitat (Lack 1986). Such variables could be controlled more stringently in the design of timed count surveys, but in practice they rarely are and the results have less precision than those from transect or point counts because of varying observer effort. Lack of control over observers tend to accentuate the problems associated with all types of census (as outlined below). Such effects need to be investigated at an early stage to define the accuracy and precision of timed counts under different circumstances and regimes. However, timed counts have the considerable advantage of being an easy technique for recorders: it will result in more participation by amateur birdwatchers than one that relies upon a more rigorous and exacting census technique.

Factors that affect the efficiency of surveys can bias the results and should be controlled as much as possible within the design of the survey. Such factors include:

a) Body Size - larger species and larger individuals within a species are often more visible than smaller ones. This could affect counts of species with marked sexual size dimorphism (e.g. Sparrowhawk (Newton 1986)).

b) Activity Cycle - censuses should take into account whether species are diurnal, crepuscular or nocturnal. If activity

varies throughout the day, censuses should be controlled accordingly.

c) Habitat and Topography - the detectability of raptors in structurally simple (e.g. marshland) habitats and topography should be assessed. Surveys should be divided into clearly defined sections of each type of habitat so that relative abundances in each can be measured.

d) Flight Behaviour - soaring birds are usually more obvious than perched ones. Knowledge of how and why flight behaviour might change is important in census design.

e) Display - aggressive defence of nesting areas and highly visible or audible displays increase detectability and vary with environmental conditions and season.

f) Age of birds - immatures may behave differently from adults, affecting their detectability.

g) Sex of birds - differences in the behaviour of the sexes can affect their detectability. Females often sit tight on the nest for the duration of incubation, while males forage to feed them. Habitat segregation occurs in Sparrowhawks: females use open farmland and males use closed woodland (Newton 1986).

h) Seasonal activity cycles - variation of behaviour during the year is crucially important to the efficiency of censuses.

i) Weather - inclement weather affects visibility and bird behaviour. Wet (and sometimes windy) weather can severely decrease the detectability of raptors and should usually be avoided.

j) Population Levels - at higher densities and population levels, birds may be relatively more conspicuous than at lower densities because of increased antagonistic interactions. At higher population levels, a wider range of habitats might be used (e.g. O'Connor 1982 for Kestrel), which should be taken into account when deciding sampling strategies.

k) Observer variability and error - observers should be familiar with survey objectives, with distinguishing species, age and sex, with bird behaviour and local habitat use by raptors. Training, practice and discussion is important to decrease variability and error.

Careful design of surveys should be able successfully to take into account these potentially biasing factors and careful recording of environmental factors will be required to allow accurate and precise data analysis. However it is likely that within a certain habitat, most factors such as weather or vegetation structure will affect the various species living there in similar ways. Thus although surveys should be designed

initially on a species-by-species basis, it should be quite feasible to combine them within a single survey suitable for a particular habitat or region. This will increase the cost-effectiveness and practicality of such surveys for general raptor monitoring.

2.2 Nest site surveys

Searches for raptor nests can provide either absolute or relative estimates of breeding population densities.

a) Relative abundances can be obtained from transect surveys for nests. Such surveys suffer from many of the biases outlined in the previous section. Furthermore, nests occur at lower abundances than birds, and large areas have to be searched to obtain a sufficient number of nest sightings for statistical analysis and comparison. For these reasons, transect surveys for nests are very unlikely to be useful in the UK. (They can be useful for surveys of species with large, conspicuous nests in countries with large, remote and uninhabited regions (Fuller & Mosher 1987)).

Relative abundance indices have been obtained in Finland by measuring the occupancy rate of nestboxes and natural nest sites (Haapala & Saurola 1989). For nestbox species, these indices are probably robust, given sufficient sample sizes and a lack of alternative natural sites. The success of the Finnish programme is due to many of their owl species nesting primarily in nestboxes (Saurola 1989); a lack of occupancy can be taken to mean a lack of breeding. In areas where natural nest sites are abundant (eg.: deciduous woodland), then lack of occupancy could mean breeding in a natural site. However, these indices could be biased by long-term changes in the siting and density of boxes and in their distribution with respect to geography and habitat.

For species using natural sites, relative abundance indices are likely to suffer from variations in observer effort and from biases toward the checking of traditional and conspicuous sites. These biases are considered in more detail below, but they are likely to cause significant error. Unless the biases are closely controlled or measured, then such indices are not reliable. If a set of traditional sites is checked for occupancy, then a useful index of relative abundance can be obtained if the suitability of traditional sites do not change. If the population is near the carrying capacity of the environment, then regular monitoring of sites will not detect minor fluctuations or large increases, but it will detect major declines.

b) Absolute abundances of breeding raptors are obtained from thorough searches for nests in clearly delineated areas. Nest searches require good knowledge of the breeding biology of the species and of the area. (An important part of any monitoring scheme should be to feedback information on basic breeding biology to fieldworkers to increase their skill and efficiency). Observations of breeding behaviour and displays can reveal nest sites. Additional information should be obtained from historical records and local inhabitants (Fuller & Mosher 1987).

Thorough nest searches require very intensive fieldwork effort (Fuller & Mosher 1987; Newton 1979, 1986; Steenhof 1987). Searches should be undertaken early in the season to detect pairs which abandon breeding before nest building, laying or hatching. Late season searches in apparently empty areas will detect late breeders or those which were missed early on. Fieldworkers should be aware that easily-found, conspicuous nests need not be a pair's only nest, searches for other less conspicuous nests should be made if breeding does not occur in the conspicuous one. For certain species, the use of traditional sites makes nest searching easier, but it is important that effort is directed into searching parts of a study area previously unused for nesting. Where two or more alternative nest sites occur within one home range, their occupation by two or more pairs should be definitely ruled out and any cases of polygyny recorded.

The intensiveness of fieldwork required for thorough nest searches necessitates the recording of observer effort to allow assessment of search efficiency. Effort variation leads to large variance within the results of different studies and decreases their usefulness for comparison (I Newton, pers. comm). An indication of this was revealed by Village's (1984) analysis of Kestrel survey results: population densities decreased as survey area increased, a phenomenon that Village ascribed mainly to decreasing survey thoroughness.

Although only relatively small areas can be searched thoroughly for nests, it is possible to extrapolate the results to wider areas on the basis of habitat use (e.g. Haworth & Fielding 1988). The use of remote sensing for mapping habitat distribution might allow useful large-scale extrapolations of population size from small-scale studies (Bignal et al. 1988); it would provide a form of indirect monitoring to provide background information for direct monitoring of raptor populations.

2.3 Territory mapping

Territory mapping can provide absolute estimates of breeding bird density within an area. The fieldwork is intensive, requiring repeated visits to an area during the breeding season to record the locations of birds and the occurrence of territorial activity. Composite maps of all records for a species are used to identify territorial boundaries (IBCC 1970). Generally, raptors occur at too low a density, are too cryptic or have overlapping territories, so that territory mapping is not useful (J. Marchant, pers. comm.) However territory mapping has been used successfully for measuring Tawny Owl breeding densities, with the addition of call-playback (Southern 1970). The only other species for which the technique might be useful is the Little Owl, but based on sight records; this needs to be tested.

2.4 Population variation

To interpret monitoring data for any population it is important to understand causes of natural variation or at least be able to explain such variation in terms of correlations with environmental factors such as weather or the abundance of food.

The majority of populations of raptors have been found to fluctuate in response to their food supply (Newton 1979). Particularly marked fluctuations occur in raptor species that feed on small mammals that show high-amplitude, short-term population cycling (with a three of four year periodicity). This is a problem that can be overcome by relating data on raptors to those on small mammal populations. Unfortunately for the national population monitoring proposed, small mammal populations in different regions of Britain do not always cycle synchronously but depend to some extent on the degree of tree fruiting each year (Charles 1981, Mallorie & Flowerdew 1988). Reliable monitoring of the populations of raptors that depend on small mammals can only be obtained by calibrating census results with data from study areas with known small mammal populations. Without such calibration such fluctuations will only allow the detection of trends in population size over periods of 10-20 years, unless a very large changes occur. However, national sets of small mammal monitoring sites, using standardised grids of Longworth traps, are operated annually by the Mammal Society in woodland (c. 30 sites) and MAFF by hedgerows (c. 20 sites), which could provide the data required for interpreting raptor monitoring results. Indeed, raptor monitoring could provide a stimulus for increased small mammal monitoring by the Mammal Society that could perhaps be supported as part of a NRMS.

The Mammal Society National Survey of Woodland Small Rodents started in 1982 and is currently under review (J.R.Flowerdew, per litt.). Study areas in deciduous woodland are monitored in May/June and November/December by placing 98 Longworth live traps on a 7x7 grid, 2 traps per point, at 15 m intervals to cover an area of 0.81 ha. The total catch of Wood Mice (Apodemus) and Bank Voles (Clethrionomys) over three days in each season are recorded. The aim of the study is to investigate the influence of tree fruiting on population fluctuations and to look for evidence of synchronicity of fluctuations between different mammal populations. The participants are volunteers from University Departments, Wildlife Trusts and Field Clubs and it forms part of the work of a number of Field Studies Council employees and by the NCC in North Wales. There are some proposals to change the emphasis of the survey toward small rodents in grassland (particularly the Field Vole Microtus), but no decisions have yet been made and the organisers are willing to consider collaboration with a NRMS. Attempts to increase the number of sites surveyed will be limited by the cost of providing 98 traps at c. £15 each.

Population densities of raptors can be affected by many other features of their environment (Newton 1979). National censuses of raptors must included a rigorous element of the stratification of samples to allow for the effects of habitat, altitude, geographical location and any important species-specific factor. With reference to geographical and habitat factors, the conventional habitat divisions used in the study of birds (eg: Fuller 1982) may be too small to describe adequately the wide-scale use of land by some species of raptor. The land-type classification developed by ITE (Bunce 1986), based on

climatological/geographical/topological measures, may be a useful system; this is currently being investigated by the NCC (C.A.Galbraith, pers. comm.).

2.5 Summary

1. Census methods for breeding raptors can be biassed by a wide range of factors that can be controlled adequately within a carefully designed survey. Data collection should be carefully stratified (according to region, land-type, habitat etc.,) to ensure that species-specific biases are controlled.

2. Useful indices of relative abundance can be obtained from transect surveys, point counts (with or without call-playback) timed counts and nest site surveys, as long as there is careful standardisation of methods, observer effort and habitat recording.

3. The occupation rate of nest sites should be used only to estimate the relative abundance of species that nest primarily in traditional sites or nestboxes. (If occupation rate is near 100%, then only major population declines can be deduced).

4. Thorough nest searches in small areas can provide accurate and reliable estimates of absolute abundance of raptors. The fieldwork effort required is large and variation in effort can bias results seriously. Territory mapping is useful for very vocal or visible species.

5. If populations show marked fluctuations then frequently repeated censuses are required to establish the normal range of variation; it is possible for populations to show cyclic fluctuations in size in response to small mammal (prey) numbers. For such highly-varying populations, trends will only be detailed over long time periods, unless raptor population trends are calibrated with small mammal surveys, such as those made by the Mammal Society and MAFF.

3. MONITORING BREEDING SUCCESS

The main objectives of monitoring breeding in raptors are two-fold: (1) to detect serious declines in reproductive performance and, when they occur, to (2) identify which part of the breeding cycle is affected and, if possible, why. Ultimately it should be possible to develop population models that show whether a population is producing young at a rate above the "recruitment standard" (below which it would decline) and to understand the density dependent mechanisms involved in the population regulation of raptors.

During egg formation and incubation, female raptors are dependent on their mate for food. If food supplies are poor, or bad weather detrimentally affects hunting during this phase, breeding can be abandoned before eggs are laid. It is therefore important to count the number of pairs on nesting territories very early on in the breeding season. An erroneous estimate of population productivity would be produced from late-season monitoring if, for example, 90% of pairs failed to lay eggs due to poor weather conditions early on, but the 10% of pairs that did lay (and that were monitored) had a very successful fledging rate. It will be impossible to monitor those birds that opt out of breeding entirely for a year, but it should be possible to monitor those that show some initiation of breeding behaviours and it is very important to include those individuals that start laying.

The fieldwork involved in nest studies is very intensive and requires specialist workers who know their species and their study area well (as described for thorough nest counts in Section 2.2). It is essential, whenever possible, to compare results of specialist and professional with those of fieldworkers who cannot devote so much time to their raptor studies, to assess the reliability and comparability of their data. To avoid any bias to conspicuous or easily accessible nests, it is important that an effort is made to find all nests in an area. Fieldworkers should strive to find all alternative nest sites in each home range and should check each area for late or missed nests. Some measure of search effort should be made, and searches should include new areas as well as traditionally used sites. It would be useful if traditional sites were distinguished from recently occupied sites because the latter are likely to be used by more subordinate or inexperienced birds than the former.

A detailed record of each site should be made which describes habitat and nest site. It would be useful to record the location by a six-figure grid reference so that further details of habitats and topography could be obtained from maps. Comparison of breeding data with geographical location and habitat, and with national data sets of topography, land use, weather, pollutant levels and especially food supply will help to elucidate the factors that affect breeding success. Knowledge of population density can be used to show which, if any, aspects of the breeding cycle are affected in a density dependent manner.

Within a defined study area, records should be kept of:

a) Number of ranges checked,
b) Number of ranges occupied before laying,
c) Number of ranges in which eggs are laid,
d) Number of ranges in which fledglings are produced,
e) Number of eggs in each nest; and laying date,
f) Hatching success in each nest,
g) Number of nestlings in each nest, (preferably at early and late stages),
h) Fledging success from each nest.

Fledging success is difficult to measure but nestling raptors usually suffer very little mortality once 80% grown and it is often assumed that fledging will be successful once they reach this age (Steenhof 1987) (This needs to be confirmed for individual species because death from starvation can occur after thus cut off point in Tawny Owls (S.M. Percival, pers. obs.). Causes of failure can be difficult to ascertain because bad weather causes a females to spend less time at her nest and thereby allow predation of her eggs or nestlings. In some species, nestlings leave the nest some time before fledging and it is very difficult to calculate their fledging success so survival to a species-specific age would have to be used instead. Measures of (e-h) above should be calculated for all potential pairs, laying pairs and successful pairs. The value (h/b) (i.e.: no. fledglings per occupied range), is important for estimating the overall production of species for conservation purposes, but it is one of the most difficult measures to obtain. If (h/b) cannot be measured, then other measures such as (h/c) will still provide useful indications of how well a population has reproduced in any year. Given accurate enough information, a key factor analysis would show which, if any, aspect of the breeding cycle is most important in determining population levels (e.g.: Newton 1988).

If each visit to a nest is recorded, then egg and nestling survival rates can be calculated using Mayfield methods (Mayfield 1961, 1975; Hensler & Nichols 1981; Johnson 1979; Dow 1978; Steenhof 1987). These methods have the advantage of using "incomplete data" from nests that could not be followed throughout the season. Mayfield's approach assumes that breeding pairs fail at a constant rate during certain phases of the nesting season. A daily nest failure rate can be calculated from the numbers of failures divided by the total number of days "exposure" of the study-nests. Each nest was exposed to failure from the first visit to the last and the sum of these durations for all study nests is used to calculate the daily failure rate. Failure rates often vary over different parts of nesting and so different rates may have to be calculated for eg: incubation and nestling phases. These rates can be applied to each phase of the nesting period to calculate overall failure rates for the population. Confidence intervals of the daily failure rates and overall failure rates over longer periods can be estimated using the techniques of Hensler (1985).

Useful information can be derived from measurements of egg dimensions and weight and of nestling growth (Percival 1988). Egg

density is correlated strongly with incubation duration and some aspects of nestling growth are good predictors of age and sex. Ringing of nestlings can confirm successful fledging and allow calculation of survival rates.

It is very important that detailed visit data are sent to a NRMS and not just a summary or the observer's own estimates of brood size etc. as is currently made on the NCC Schedule 1 Licence Report Form (Fig. 3.1). To record all the information in a standardised and useful manner, it is suggested that the new BTO Nest Record Card be used (Fig 3.2). Some Raptor Study Groups already use detailed recording forms (eg: Fig. 3.3) but if recorders do not wish to submit information on their visits to the nests of Schedule 1 species, then a detailed recording form should be submitted to the NCC for all sites that are checked, whether occupied or not. A suggested design for a detailed report form is given in Fig. 3.4 and a summary form, to be submitted if BTO Nest Record Cards have been completed, is shown in Fig. 3.5. (Photocopies of BTO Nest Record Cards for Schedule 1 species could be held by the NCC). It is imperative for the NCC to receive useful information, for conservation and monitoring purposes, from people licensed to disturb the nests of Schedule 1 species, otherwise there is little reason for such licenses to be granted.

Given the labour-intensive nature of raptor nest-site recording, only relatively small areas can be checked thoroughly for most species. For the derivation of trends over a number of years, it would be useful to define a set of "annually checked nest sites or areas" that are checked each year. Information from other sites would be important for comparison and extra information, but the regular checking of a set of annually checked sites is essential. The set of annually checked sites should be stratified according to land-type, habitat, nest site, and geographical location in order to provide a reasonably representative sample for the country as a whole. A higher rate of visiting to annually checked sites would provide more useful information than a lower rate to a greater number of sites because the accuracy with which one can calculate factors (e-h, above) increases with visit frequency. However, maximum amounts of information could be obtained from relatively few well-planned visits to many nests. Sampling strategies will be examined in Phase 2 of this project.

As for population sizes the reproductive rates of some species vary widely in response to small mammal (prey) numbers. Careful assessments of small mammal numbers in each study area would be most desirable, but calibration of results with those from areas with known populations (from Mammal Society or MAFF Surveys) would be important for achieving reliable monitoring. Without such calibration, the elucidation of trends in reproductive variables for such raptors may be possible only over relatively long time spans (e.g: 10-20 years).

3.1 Summary

1. Monitoring the breeding success of raptors requires intensive fieldwork over relatively small areas by specialists. It is

essential whenever possible, to compare the results of intensive studies with extensive studies, to assess accuracy and reliability.

2. Observations must begin early in the season to include early failures.

3. A set of "annually checked nest sites" should be monitored every year, stratified according to habitat, geographical location and other factors of importance, to provide a representative sample for the country and its regions.

4. Information on nest sites and nest visiting should be recorded on the new BTO Nest Record Card, whether the site is occupied or not. If recorders of Schedule 1 species do not wish to submit BTO Nest Record Cards, then detailed information should be sent to the NCC on a recording form, such as is shown in Fig. 3.4. The current NCC Licence Report Form is not adequate for providing useful information for conservation and monitoring purposes.

5. Measurement of egg density and nestling size is desirable to allow accurate ageing of nest contents, thereby minimizing the numbers of visits to each nest.

6. For species that show wide annual variations in reproductive variables in response to small mammal numbers, overall trends of change may only be detectable over relatively long periods unless calibrated with surveys of small mammal populations as carried out by the Mammal Society and MAFF.

Fig 3.1: NCC Schedule 1 Licence Report Form

CONFIDENTIAL LICENCE REPORT FORM FOR SCHEDULE 1 BIRDS

Wildlife and Countryside Act 1981 : Section 16(1)(a)(c)(h)

Please complete and return this form to :
for the attention of in accordance with the conditions of your licence
Please note that an inadequate return will prejudice future licence applications. Informati
obtained from returns is essential to the operation of the system for conservation ;
locations of nests are required and will be treated in strict confidence.

Species (one form per species)	BLOCK LETTERS PLEASE Licensee's Name ..... and Address .....

County and Name of site(s) with (six figured) grid ref.	No of pairs. If known please give clutch size, brood size and fledging dates.	No of visits to nest site and dates

Comments. We do not wish to encourage disturbance to obtain details but hope that all known facts will be noted here eg (1) habitat, (2) present or future threats, (3) public or private site, (4) conservation measures considered necessary, (5) reasons for success or failure, (6) if there were other birds of this species in the area which you believe were also breeding.

The above records have been reported to the county/regional report editor. Yes/No
If no, he/she may be informed. Yes/No
If no, this record may be submitted only to the rare breeding birds panel.
In circumstances where the information is considered important for conservations reasons it may be passed to the appropriate regional office of the NCC.

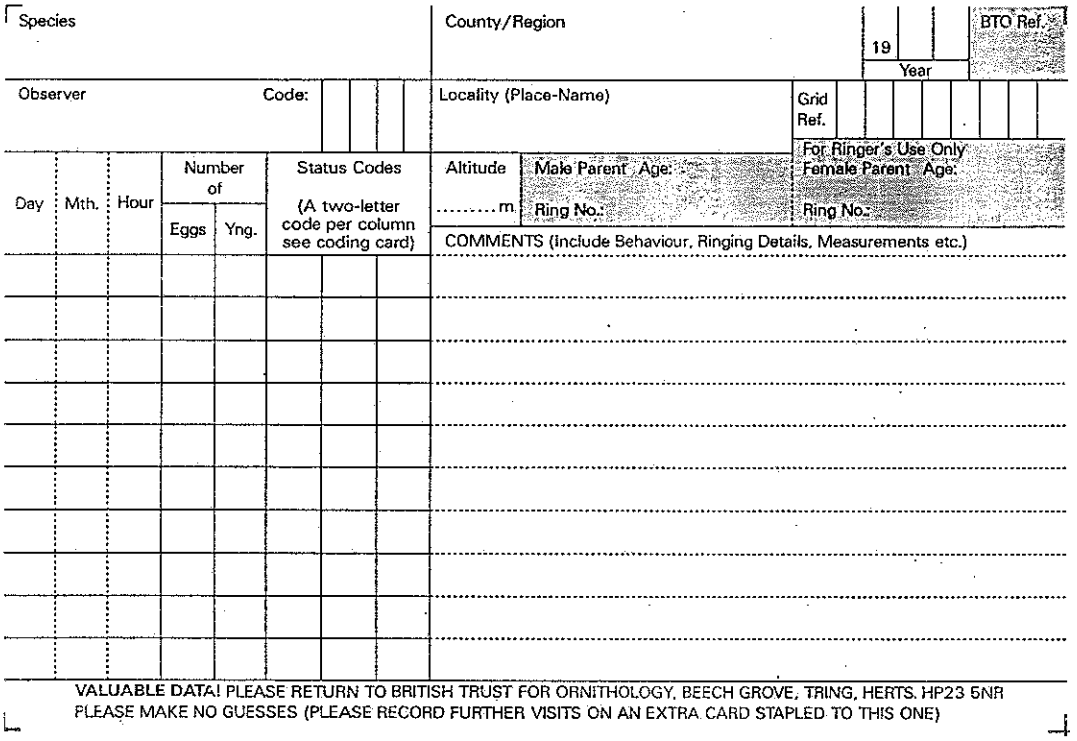
Please give details including dates of any consultations undertaken as part of licence conditions.

Were Nest Record Cards submitted to the British Trust for Ornithology for any of the nests listed above?

Signature.....

Date.....

Fig 3.2: The New BTO Nest Record Card



Species | County/Region | 19 Year | BTO Ref.

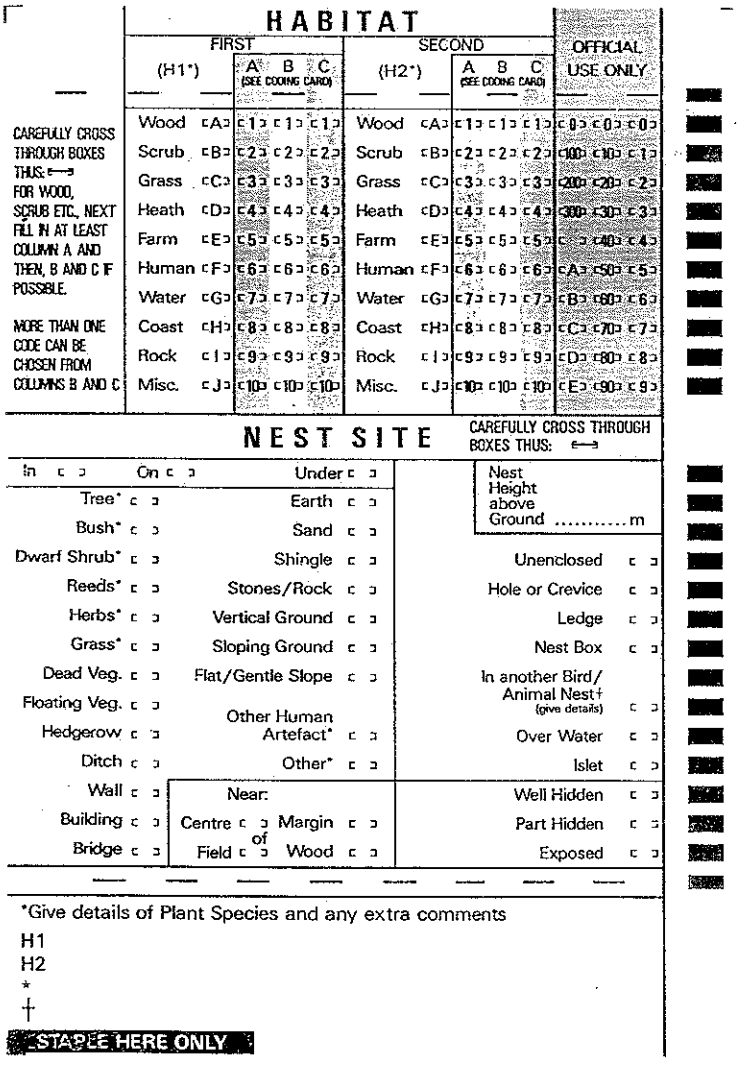
Observer | Code: | Locality (Place-Name) | Grid Ref.

For Ringer's Use Only

Day | Mth. | Hour | Number of: Eggs, Yng. | Status Codes (A two-letter code per column see coding card) | Altitude ..... m | Male Parent Age: Ring No.: | Female Parent Age: Ring No.:

COMMENTS (include Behaviour, Ringing Details, Measurements etc.)

VALUABLE DATA! PLEASE RETURN TO BRITISH TRUST FOR ORNITHOLOGY, BEECH GROVE, TRING, HERTS. HP23 5NR
PLEASE MAKE NO GUESSES (PLEASE RECORD FURTHER VISITS ON AN EXTRA CARD STAPLED TO THIS ONE)



HABITAT

	FIRST (H1*)	A	B	C (SEE CODING CARD)	SECOND (H2*)	A	B	C (SEE CODING CARD)	OFFICIAL USE ONLY
CAREFULLY CROSS THROUGH BOXES THUS: ⟷ FOR WOOD, SCRUB ETC., NEXT FILL IN AT LEAST COLUMN A AND THEN, B AND C IF POSSIBLE. MORE THAN ONE CODE CAN BE CHOSEN FROM COLUMNS B AND C	Wood	A	1	1	Wood	A	1	1	0 0
	Scrub	B	2	2	Scrub	B	2	2	10 1
	Grass	C	3	3	Grass	C	3	3	20 2
	Heath	D	4	4	Heath	D	4	4	30 3
	Farm	E	5	5	Farm	E	5	5	40 4
	Human	F	6	6	Human	F	6	6	A 50 5
	Water	G	7	7	Water	G	7	7	B 60 6
	Coast	H	8	8	Coast	H	8	8	C 70 7
	Rock	I	9	9	Rock	I	9	9	D 80 8
	Misc.	J	10	10	Misc.	J	10	10	E 90 9

NEST SITE — CAREFULLY CROSS THROUGH BOXES THUS: ⟷

In	On	Under		
	Tree*	Earth	Nest Height above Ground ..... m	
	Bush*	Sand		
	Dwarf Shrub*	Shingle	Unenclosed	
	Reeds*	Stones/Rock	Hole or Crevice	
	Herbs*	Vertical Ground	Ledge	
	Grass*	Sloping Ground	Nest Box	
	Dead Veg.	Flat/Gentle Slope	In another Bird/Animal Nest† (give details)	
	Floating Veg.	Other Human Artefact*	Over Water	
	Hedgerow	Other*	Islet	
	Ditch	Near:	Well Hidden	
	Wall	Centre of Field	Margin of Wood	Part Hidden
	Building			Exposed
	Bridge			

*Give details of Plant Species and any extra comments

H1
H2
*
†

STAPLE HERE ONLY

Fig 3.3: Recording Form Used by North-East Scotland R.S.G.

CONFIDENTIAL RAPTOR / RAVEN SITE RECORD

site year _____ code _____

species _____

map ref _____ county & region _____, _____

observers _____

SKETCH OF SITE: indicate nest

direction of view for sketch _____

aspect of cliff/hillside

aspect of nest _____

altitude of nest (m) _____

cliff/tree height(m) _____

nest height up cliff/tree(m) _____

nest position(cliff,bank,tree,etc

nest type(scrape,crow nest,etc)

SITE VISITS

date	times	no./status of birds, state/contents of nest, weather(if useful),etc

ring nos, + sex, age of chicks

PREY ITEMS-note date, species, number

alternate sites-name,map ref,dates checked

LAND USE-% area within 1km of nest site covered by

farmland	grassland	moor	cliffs,screes	plant'ns	broadl'vs	

COMMENTS- disturbance level,estate attitude,habitat changes,history of site,etc

SUMMARY	birds present	eggs laid	small young	large young	fledged young

Fig. 3.4 Suggested design for the NCC Schedule 1 Report Form if BTO Nest Record Cards are not submitted.

CONFIDENTIAL LICENCE REPORT FORM FOR SCHEDULE 1 BIRDS

Wildlife and Countryside Act 1981 : Section 16(1)(a)(c)(h)

FOR USE IF INFORMATION HAS NOT BEEN SUBMITTED ON BRITISH TRUST FOR ORNITHOLOGY NEST RECORD CARDS. Please complete and return this form to ..... for the attention of..... in accordance with the conditions of your licence. Please note that an inadequate return will prejudice future licence applications. Information obtained from returns is essential to the operation of the system for conservation; locations of nests are required and will be treated in strict confidence. COMPLETE ONE FORM PER NEST

SPECIES	LICENSEE'S NAME
COUNTY	SITE NAME
GRID REFERENCE (eg: TN135793)	ALTITUDE (m)

VISIT DATA Day	Month	Year	Number of Eggs	Young	Stage of nest, presence of adults reasons for success/failure etc.

Measurements of eggs/young, if taken; Ring Numbers and sex of chicks:

Habitat description (please use BTO Habitat codes if possible)

Details of any consultations made as part of licence conditions including dates:

Fig. 3.5 Suggested design for NCC Licence Report Form for use when BTO Nest Record Cards have been submitted

CONFIDENTIAL LICENCE REPORT FORM FOR SCHEDULE 1 BIRDS

Wildlife and Countryside Act 1981 : Section 16(1)(a)(c)(h)

FOR USE IF INFORMATION HAS BEEN SUBMITTED ON BRITISH TRUST FOR ORNITHOLOGY NEST RECORD CARDS. Please complete and return this form to ..... for the attention of..... in accordance with the conditions of your licence. Please note that an inadequate return will prejudice future licence applications. Information obtained from returns is essential to the operation of the system for conservation; locations of nests are required and will be treated in strict confidence.

SPECIES		LICENSEE'S NAME
SITE NAME	COUNTY	GRID REFERENCE (eg: TQ 175936)

Details of any consultations made as part of licence conditions including dates:

4. MONITORING SURVIVAL RATES

Three types of data can potentially be used to estimate survival rates of raptors: counts of the ratio of adults to immatures, ringing recoveries and mark-recapture/resighting data. Methods of estimating survival from counting the proportions of each age class using age-dependent plumage characteristics suffer from differences in the behaviour of adult and immature birds. Such estimates are thus too prone to error to be useful for accurate monitoring of survival (Newton 1979), and will not be considered further here.

4.1 Survival estimation from ringing recoveries

The BTO Ringing Scheme holds all ringing and recovery data for raptors ringed in Britain and Ireland. Since 1982 the ringing of raptors in Britain has been promoted through the provision of a full rebate of the cost of the rings used as part of the NCC Target Species system. This has proved to be an effective and low cost means of promoting the ringing of raptors and the consequent visiting of raptor nests for monitoring purposes. Rebates paid to ringers currently total about £775 per year for raptors and owls. These rebates represent a very small proportion of the costs paid by field-workers, but they provide a important indication that the NCC and the BTO value the work. It is strongly recommended that such ring subsidies should continue within the context of a NRMS. The vast majority of raptors ringed in Britain and Ireland are marked as chicks (Mead and Clark 1988, chapter 6). Discussion of analytical methods is therefore limited to the case where all birds are ringed as young.

All recovery data are computerised. Ringing data (for birds which have not been recovered) are not computerised except for most data on Tawny Owl and Barn Owl that have been computerised for the owls project being undertaken by S.M.P. The BTO has long-term plans for the computerisation of all ringing data (Green et al. 1987) and some aspects of this are included within the NCC/BTO contract. Time-specific and age-specific distributions of recoveries are functions of the number of birds ringed and of subsequent survival and reporting rates. It is essential, therefore, that ringing data should be computerised if the best use is to be made of the recovery information. This will be particularly important if survival rates are required for birds ringed in different regions. Totals of raptor chicks ringed over the whole of Great Britain and Ireland are calculated annually from totals lists submitted by ringers. In the future it could be possible to obtain data on age of broods and nesting habitat for nests which are not entered on Nest Record Cards, if such information was recorded on computerised ringing schedules.

The development of methods for the analysis of ringing recoveries has received considerable attention over the last 15 years (Brownie et al. 1985, North 1987). There is now a well established series of models available for standard analyses (Brownie et al. 1985), including maximum-liklihood estimation of parameters,

estimation of variances and covariances, goodness-of-fit tests of the data to the models and liklihood-ratio tests between models. The general strategy employed in analysis is to consider a sequence of models of varying complexity which are appropriate to the data, and to select the simplest model which adequately describes the data. Simpler models have fewer parameters and the precision of the parameter estimates is thus improved. Software is available which allows a wide range of user-defined models to be used in situations where the standard models are inappropriate (White 1983, Conroy and Williams 1984).

Unfortunately a number of studies have now shown that there are serious difficulties in estimating age-specific survival and recovery rates when only young are ringed (Burnham and Anderson 1979, Lakhani and Newton 1983, Anderson et al. 1985, Brownie et al. 1985). There are two main problems which will be dealt with more fully in phase 2 of this project:

1. The fully age-specific or life-table model has undesirable mathematical properties which may make parameter estimates unreliable and partially dependent on the constraint used to solve the model. The problem is particularly severe with large numbers of age classes and with short runs of data. The power of goodness-of-fit tests to reject this model when it is inappropriate is weak (Burnham in press). Some recent work suggests that detailed analyses of such data sets may allow reliable conclusions to be reached (Freeman and Morgan in press, Lokki and Rinne in press).

2. Recovery rates must be assumed to be age independent if survival rates are to be estimated for first year and immature age classes. This assumption is often unrealistic because young birds and adults may differ in geographical distribution and vulnerability to different recovery circumstances, giving rise to differences in their overall recovery rates.

Given these problems and the modest numbers of recoveries available for most raptor species it is unlikely that it will be possible to estimate survival rates on an annual basis. However the following approaches should be possible:

1 Analyses of long-term changes in adult survival rates by estimating constant adult survival rates for periods of five to 10 years. This approach has been applied successfully to Danish raptors (Noer and Secher 1983, Noer in press).

2. Approaches in which survival rates are modelled in terms of co-variates. This would allow investigation of relationships between survival and such factors as weather, vole abundance and pesticide use. Such an approach has been used to investigate relationships between Grey Heron survival and winter weather (North and Morgan 1979).

3. Use of first year recovery rates as an index of first year survival. It would be necessary to assume that most variation

is due to changes in survival and not to variation in reporting rates. This may be reasonable for species which are not hunted.

4. Augmentation of the recovery analyses with additional independent data. This may allow some of the problems listed above to be overcome. For example mark-recapture data might provide additional data on adult survival rates. One aim of current methodological developments should be to develop models which allow extensive recovery data from national schemes to be combined with mark-recapture data from intensive studies (Buckland and Baillie 1987).

It would probably be impractical to attempt to increase the ringing of adults for most species (below). However if it were possible to promote extensive ringing of adults for the more common species the value of the recovery analyses which could be carried out would be increased substantially.

Possibilities for estimating survival rates from recoveries of raptors ringed in Britain will be explored further in phase 2 of this project. Sample sizes for the various types of analyses discussed above will be examined.

4.2 Survival estimation from mark-recapture data

Most raptors are difficult to catch as adults. However for many species a high proportion of breeding females can be caught at the nest, and this disturbance does not impair breeding success (Newton, pers. comm.). Useful results can be obtained only if a high proportion of females are caught each year over a period of several years. Five years would perhaps be the minimum length of study that should be attempted. The study area must be large relative to the breeding dispersal distances of individual females so that large numbers of birds are not lost from the study due to emigration.

Survival rates of males cannot be studied in this way as it is often not possible to catch a sufficiently high proportion of individuals. However, traps set at nestboxes have been used successfully by Finnish workers to catch male owls (Saurola 1989). Absolute survival between fledging and breeding cannot be estimated because not all birds return to breed in their natal area. However it might sometimes be possible to obtain an index of immature survival using data of this kind, and to assess the effect of factors such as laying date and fledging weight on immature survival.

Statistical methodology similar to that for ringing recoveries has been developed for mark-recapture data (Buckland 1982, Clobert et al. 1987, Pollock et al. 1990).

A number of successful mark-recapture studies of raptors have been undertaken (Buzzard, Weir in Newton 1979; Sparrowhawk, Newton et al. 1983; Peregrine, Newton and Mearns 1987). However all of these

studies have involved very intensive work by professional ornithologists. It may be possible to develop a number of specifically targeted mark-recapture studies of selected species within the context of a NRMS. However it would probably be undesirable to promote widespread nest trapping because it is unlikely that sufficient intensity would be achieved. Despite evidence that nest-trapping does not disrupt breeding, sensitivities to the promotion of this type of activity both within the raptor community and beyond must be taken into account.

4.3 Summary

1. Large numbers of raptor chicks are ringed each year, and recoveries of these birds may be used to monitor the survival rates of raptors.

2 Raptor ringing has been promoted by providing rebates to cover the full cost of rings, and it is recommended that this should continue.

3. Ringing data for raptors need to be computerised to allow full analysis of the resulting recoveries.

4. Methodologies for the analysis of ringing recoveries are outlined briefly.

5. Because nearly all raptors are ringed as chicks analytical problems arise which will limit the analyses which can be undertaken.

6. Detection of long-term changes in survival, identification of covariates of survival and indexing of first year survival should all be possible for some species. Phase 2 of this study will examine these options in more detail.

7. It will not usually be possible to obtain year-specific survival estimates, nor to obtain survival estimates for individual age classes.

8. Mark recapture studies of breeding females offer a powerful method for obtaining high quality data on the survival rates of this group. Such studies will only be possible where a very high level of field-work input can be guaranteed, and should not be promoted more widely.

5. RAPTOR FIELDWORKERS IN BRITAIN

A great deal of fieldwork is currently being undertaken on raptors in Britain, a large amount of it by amateurs. In this section an outline is given of the major groupings of fieldworkers or sources of information on raptors. Further details are given in the species accounts later.

BTO

The BTO coordinates and promotes active ornithological fieldwork, at a national level, designed to produce scientifically useful results often particularly useful for conservation purposes. It consists of c. 8,000 members and has a staff of 50 (including 30 scientists). Many aspects of the BTO's research programmes provide important information on raptor populations.

(i) Nest Record Scheme

Finance: NCC, BTO
Membership: c. 1000, voluntary, open to all.
Information gathered: nesting details are recorded on special Nest Record Cards (NRCs), including habitat, visiting data and location.
No. of raptor NRCs annually (1988): 1911.
Total no. raptors NRCs held (1939-88): 22,279, (all computerised).

(ii) Ringing Scheme

Finance: Ringers (via charges for rings and license fees), NCC, BTO
Membership: c. 2000, compulsory licensing of ringing activity within the U.K.
Information gathered: Where and when birds are ringed with unique BTO rings; recovery details of dead birds; retrap details of live birds that moved more than 5 km from place of ringing.
Raptors ringed annually (1987): 933 adults, 6175 pulli
Total raptors reported (1909-87): 99,953 ringed, 9680 recovered, (all British recoveries are computerised; ringing details are computerised for c 12,000 Tawny Owls; 8,000 Barn Owls and 2,000 Asio owls).

(iii) Raptor Research Register

Finance: BTO
Membership: voluntary, open to all.
Information gathered: details of current raptor studies in the U.K.
No. of U.K. raptor studies: 57 individuals or groups working on one or more species.

(iv) Owls Project

Finance: Four agrochemical companies (Ciba-Geigy, ICI, Shell, Sorex) and BTO (3 years 1987-90).
Membership: BTO members and specialists: c. 40 for breeding studies, c. 500-1000 for surveys.
Aims: to examine factors affecting population dynamics of Tawny and Barn Owls: by developing a national network of

specialist nest recorders, by undertaking national population surveys and by analysis of BTO data archives.

(v) Common Birds Census
Finance: NCC, BTO
Membership: c. 200, voluntary, open to all.
Information gathered: Territory mapping censuses on c. 200 plots to produce annual population indices. Although indices for Kestrel, Sparrowhawk, Tawny and Little Owls are produced, they are neither very sensitive to changes nor useful for calculating population densities because plot size is usually smaller than territory size. However, they have provided a useful guide to overall historical trends in the combined population size of breeding and non-breeding birds. (All count data are computerised).

(vi) Colour-mark Register
Finance: membership
Membership: Compulsory (licence requirement by NCC)
Information gathered: Species and colour combinations. Sightings are not collected but passed on to licensees.
No. of raptor studies: 12

(vii) Atlas studies and special surveys
Finance: various sponsors, BTO, NCC
Membership: BTO +
Information gathered: National atlases of (a) breeding distribution 1968-72 (Sharrock 1976), (b) winter distribution and relative abundance 1981-84 (Lack 1986), (c) breeding distribution and relative abundance 1988-90 (Gibbons 1989). Special single species distribution and abundance surveys including: Hobby 1949; Buzzard 1954-56; 1983; Peregrine 1961-62, 1963-64, 1965-66, 1971, 1981.

5.2 NCC Schedule 1 Licence Reports

Finance: NCC
Issued for: Disturbance at nests of species on Schedule 1 of Wildlife and Countryside Act 1981 (see Table 1.1). One licence per person per species.
Issued by: BTO (ringing, nest recording); RSPB (nest recording); NCC (photography or other reasons not covered by BTO, RSPB).
Information gathered: location details, nest contents and visiting dates for each disturbed nest.
Annual no. licences issued: (for Merlin, Hobby, Peregrine, Hen Harrier and Golden Eagle); c. 350 (of which c 33% are issued by BTO). Currently the NCC is streamlining the licensing system to increase the quality of reporting in general, and to improve relations with raptor workers in Raptor Study Groups in particular.

5.3 NCC

The Nature Conservancy Council was created by an act of Parliament in 1973 "for the purposes of nature conservation and fostering the understanding thereof" and replaced the Nature Conservancy established in 1949. It is the government body which promotes nature conservation and relevant research in Britain and provides advice to the government on all matters to do with conservation. It is responsible for the maintenance and creation of National Nature Reserves (currently numbering 234) and it designates areas as Sites of Special Scientific Interest (currently numbering over 5000). It has an annual budget of c. £40M funded mainly by a grant-in-aid from the Department of Environment and maintains a staff of over 1000.

The NCC supports c. 200 research projects in all branches of conservation science each year, some of which are directed toward or include fieldwork on raptors. This work is carried out by its own staff as well as through contracts to the BTO, Universities and I.T.E. and by grant aid to the voluntary sector. Of particular relevance to this review are: the 3 year NCC study by Watson et al. (1987) on the effects of land use changes on Golden Eagles in the Scottish Highlands; various projects and surveys on moorland and upland birds; a study by Glasgow University on the effects of landuse changes on scavenging and predatory birds in the Uplands; some funds for work at Edinburgh University on Barn Owls; support for the first-ever complete census of Golden Eagles in Britain (Dennis et al. 1984); long-term contract funding to ITE for monitoring pollutant levels in raptors (Cooke et al. 1982); the reintroduction and monitoring of White-tailed Eagles; work on Red Kites both in Wales and the reintroduction programme in Scotland and England; and full rebates on BTO rings used on raptors.

Grant aid is given to the Rare Breeding Birds Panel (RBBP), to the North East Scotland Raptor Study Group, to few individual specialists for monitoring Peregrine and Sparrowhawk and to the Hawk and Owl Trust (Hawk Trust) for work on Barn Owls.

NCC staff cooperate with and contribute time to fieldwork and organisational duties of various Raptor Study Groups. Particular raptor specialists include Derek Ratcliffe (Peregrines, now retired), Colin Tubbs (Buzzard), Jeff Watson (Golden Eagle) and John Love (White-tailed Eagle).

5.4 RSPB

The Royal Society for the Protection of Birds is a registered charity and has a membership of over 500,000. Its main aims are to conserve wild birds and their habitats and to provide information and education about bird conservation.

The RSPB considers that the protection of rare and persecuted raptors is an important conservation priority (Cadbury et al. 1988). Action to protect occupied nests of rare species and to stop persecution or accidental poisoning by game-keepers and farmers (Cadbury 1980) is pursued with vigour. The

organisation devotes much attention to wider land-use issues that potentially affect wide-ranging birds like raptors and it supports or carries out monitoring and scientific research which provides a basis for conservation activities. The RSPB also concentrates resources on the establishment of nature reserves and on programmes to raise public awareness of birds of prey and the need for their conservation.

Current research includes primary surveys of upland study areas, involving counts of several raptor species. The RSPB has defined a set of priorities amongst the Red Data Book Birds and will be pursuing conservation and reserach programmes on these species. In 1989, a national survey co-ordinated by the RSPB should provide the first formal population estimate for Hen Harriers. The RSPB also jointly co-ordinated the national survey of Golden Eagles that was supported by NCC funding (Dennis et al. 1984), has undertaken much research on Merlin ecology (eg.: Bibby 1986, Bibby & Nattrass 1986), on monitoring populations of Red Kites, Ospreys and White-tailed Sea-Eagles, Golden Eagles, Short-eared Owls and Peregrines, and co-operates extensively with the NCC, ITE and BTO on a number of projects involving raptors. John Cayford has been employed to undertake a three-year study of the ecology of the Barn Owl.

Except for specific localised problems, the RSPB does not expend effort on relatively common raptors such as Kestrel or Tawny Owl, although RSPB wardens usually monitor their reserves carefully to census the populations of notable species, like raptors, and their breeding success.

5.5 ITE, Universities and Forestry Commission

Scientists at the ITE (Institute of Terrestrial Ecology, formed from the research arm of the Nature Conservancy in 1973) and in Universities usually undertake detailed intensive projects. The most notable long-term ecological research on raptors is by I. Newton (ITE) on population ecology of Sparrowhawks, now in its 20th year and from which many publications have resulted (eg: Newton 1986, 1988). Newton has formed collaborative links with many amateur raptor fieldworkers in Britain and receives substantial quantities of breeding data on Sparrowhawks and Merlins (eg: Newton et al. 1978, 1986). Other raptor research includes or has included population studies on Goshawks (R.E. Kenward), Peregrines (Mearns & Newton 1984, 1988), Kestrels (A. Village 1981, 1982, 1983, 1990), Red Kites (with NCC) (Newton et al. 1981, Davis & Newton 1981), Buzzard (Picozzi & Weir 1974) and Hen Harrier (Picozzi 1978, 1984). Much of this work is concerned with population trends over time, with factors affecting numbers and breeding success and with the impact of different forms of land-use. The ITE is also contracted by NCC to undertake long-term monitoring of pollutant levels in birds, particularly raptors (e.g. Cooke et al. 1982, Newton & Haas 1984, Newton et al. 1989).

Glasgow University has received contracts from the NCC for the study of the effects of land-use change on scavenging and

predatory birds in the Uplands. Major parts of this work involve two PhD studentships on Buzzard and Raven. Iain Taylor at Edinburgh University has been studying the population ecology of Barn Owls since 1978 (partly funded by NCC).

Steve Petty coordinates and directs raptor studies for the Forestry Commission and in particular is continuing a long term population study of Tawny Owls in upland spruce forests (since 1981) as well as other work on Goshawks and Hen Harriers.

5.6 Raptor Study Groups

Raptor Study Groups (RSGs) were developed in Scotland in the 1980s. South of the border, ringing groups such as the Northumbria Ringing Group and Sorby-Breck Ringing Group provide a similar function, but only as part of their other activities. The North York Moors Merlin Group was formed recently and an informal group of raptor workers operates in the Lake District.

As part of this review HQPC met 16 members from six of the eight RSGs. The following discussion is a distillation of these meetings.

a) General: RSGs are semi-formal autonomous groups of voluntary raptor specialists. Only fieldworkers are accepted within RSGs, although observers from RSPB and NCC (eg. Assistant Regional Officers) may attend the meetings of some groups. Potentially untrustworthy people are excluded. Their main raison d'etre is to stop excess nest disturbance by controlling the access of recorders to each nest but to increase coverage of recording within each area by ensuring that as many nests are monitored as possible. Two group meetings are held each year: the first in February to plan the allocation of nest sites or areas between members; and the second in September to discuss the season's results. Within RSGs, there are often "species organisers" responsible for co-ordinating data gathering for each species: they ensure that all sites are checked consistently and conscientiously. If any member is unable to fulfil their commitments then other members can be asked to cover the sites. Some RSGs use standard "site record forms".

The demarcation lines between RSG areas are often arbitrary and may not follow any ecotones; for example the A71 trunk road is one such line. RSG areas are shown in Figure 5.1.

Information is collected by RSG members for their own interest and for its usefulness to conservation. Addled eggs are sent to ITE for pollutant analysis. Breeding data are released outside the group with varying degrees of freedom, but generally on a "need-to-know" basis. They are often especially wary of revealing site-location details. The majority of RSGs give data to the RSPB to aid them with site protection. Some RSGs have good relations with the local NCC AROs and the Ornithology Branch of the Chief Scientists Directorate and give data to them for the same reasons as they give data to the RSPB. The BTO receive Nest Record Cards from a substantial number of RSG members for national monitoring purposes. In general, there is both a feeling of

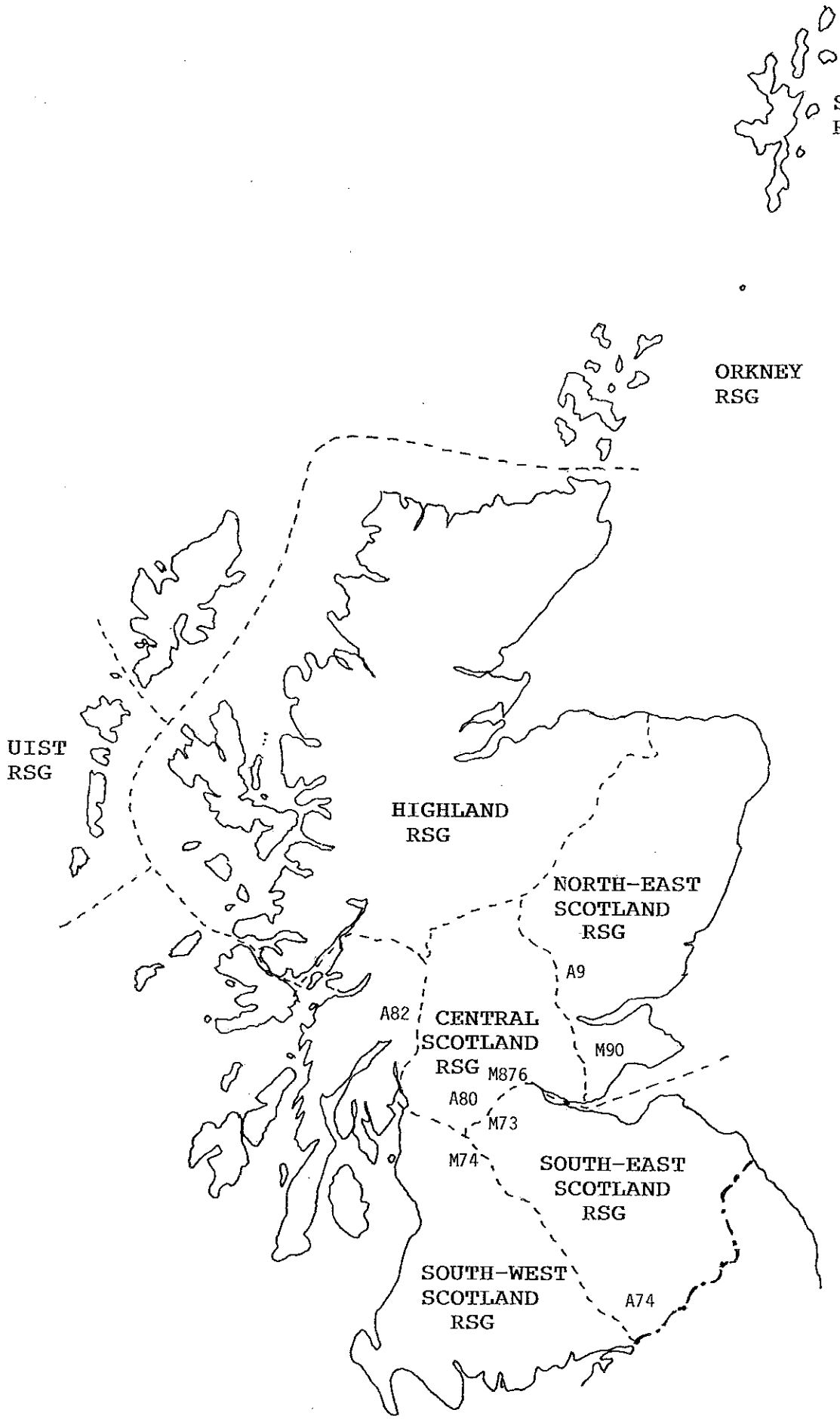


FIGURE 5.1. Scottish Raptor Study Group areas.

distrust of "NCC HQ" within a few RSGs, that has been engendered by a lack of consultation when licences have been granted to photograph or take pulli from raptor nests that were being monitored by them, as well as an atmosphere of cooperation and trust within the others. More recently however, the NCC Licensing Section has begun a policy of increasing the level of consultations with Raptor Study Groups that will be very beneficial in increasing the quantity and quality of information provided by them on their licence report forms.

b) Highland RSG - c. 25 members, formed from RSPB staff (including the co-ordinator, Roy Dennis), NCC staff and the Highland Ringing Group. Original aims were to monitor stealing of Peregrine and Golden Eagle eggs and to avoid duplicate nest visiting by members. They are considering defining a set of "core study sites" for annual monitoring. Some Nest Record Cards are sent to the BTO.

c) North-East Scotland RSG - c. 25 members, initiated by Adam Ritchie and Adam Watson (ITE) to decrease duplicate recording and increase coverage. They are not prepared to give site-by-site details to a NRMS, but would look sympathetically at any request for more detailed information than is released currently. Currently the RSG is becoming more of a pressure group, using their data to stop adverse landuse changes at important sites and to gather incriminating evidence on raptor persecutors. They have links with RSPB and some Nest Record Cards are sent to the BTO. Their links with the NCC were important in influencing the formulation of a forestry strategy by the Regional Council which took into account the needs of breeding raptors.

d) Central Scotland RSG - c. 20 members, co-ordinated by Patrick Stirling-Aird to monitor upland species (Hen Harrier, Golden Eagle, Merlin, Peregrine). All information is sent to RSPB and BTO.

e) South-East Scotland RSG - c. 8 members, co-ordinated by Dave Dick (RSPB) and Alan Heavisides. All information is sent to NCC and RSPB and some Nest Record Cards to the BTO.

f) South-West Scotland RSG - c. 24 members, co-ordinated by Dick Roxburgh. They achieve a very high coverage of upland raptors, they include Barn Owls and have a Kestrel specialist, Gordon Riddle, who monitors c. 40 nests. In 1989 they undertook a survey of Ravens because of worries over declining populations. Data are given to NCC Ornithology Branch and AROs, RSPB and some Nest Record Cards are sent to the BTO. The NCC provides some support for the group's work.

g) Orkney RSG - co-ordinated by Eric Meek, they concentrate on upland and moorland species.

h) Shetland RSG - co-ordinated by Pete Ellis, they concentrate on upland and moorland species.

i) Uist RSG - c. 7 members, co-ordinated by Tim Dix, they aim to monitor population size and breeding success of all raptors.

j) Reporting Results - A general review of each year's data is compiled by RSPB staff for Scottish Bird News (Dick & MacLeod 1986, MacLeod & Dick 1987, MacLeod 1988). These reviews give information on the numbers of ranges: (a) occupied, (b) with eggs laid, (c) with eggs hatched, (d) from which chicks fledged; as well as the total number of young fledged in each RSG area. Clearly the information presented is inadequate for monitoring, given that much of the information listed in section 3 is omitted, especially details of numbers of ranges checked, clutch size, hatching success and brood size, and that no measures of variances are given.

RSGs also produce their own individual, privately circulated reports that give more details but still not enough to make complete use of the data they have obtained (e.g. Dennis 1984, Dix 1988, Stirling-Aird 1988).

5.7 Hawk and Owl Trust (Hawk Trust)

Finance: membership and sponsorship

Membership: c. 1000

Aims: to promote the conservation and appreciation of raptors particularly by working with landowners, farmers, game-keepers and foresters who manage much of the land in Britain. It was founded in 1969 but its involvement in wild British raptors has been dominated by the Barn Owl Survey of Britain and Ireland that it organized in 1982-85, coordinated by Colin Shawyer (Shawyer 1987). The Trust has since developed an education programme and a monitoring programme (through its Barn Owl Conservation Network) focussed on its National Centre for Owl Conservation at Blickling Hall, Norfolk and is involved in several Barn Owl projects around the country including SW Scotland, Norfolk and Lincolnshire. The Barn Owl Survey was a very useful first step in the investigation of the national population decline of this species and a further survey is planned for 1992 which will presumably take into account the methodological criticisms made of the first survey (eg: Hirons 1990).

The Hawk and Owl Trust uses the services of member veterinary surgeons to advise on raptor rehabilitation and the services of member bird of prey keppers to research and advise on Barn Owl rear-and-release schemes (it has finished a programme of studies of captive breeding Merlins). The Trust is also involved in work on other birds of prey, particularly the Merlin and forest raptors in Scotland in association with the Forestry Commission, private forestry companies and game estates; a report on the Merlin project is due to be published in late 1990.

6. THE MONITORING SPECIES

Species-by-species accounts are given in this section to provide brief details of (a) breeding biology relevant to monitoring work; (b) suitable census methods; (c) techniques for monitoring reproductive success; (d) current estimates of population size and (e) how much fieldwork is being undertaken currently on each species. (Estimates of fieldwork based on Schedule 1 Licence Reports are maxima because collaborating workers need separate individual licences to visit the same nest; this bias has been eliminated as far as was possible for this review, but some over-estimation of apparent research effort is inevitable). It should be noted that some BTO Nest Record Cards for Schedule 1 species were completed without a NCC Licence because no visits to the nests were made as they could be observed from a distance without disturbing the birds, or because they were found accidentally and recorded only once.

General references that were consulted for all species were: BTO (1989); Brown 1976; Cramp 1980, 1985; Mead & Clark 1988; Mikkola 1983; NCC/RSPB (in prep); Sharrock (1976).

6.1 Hen Harrier

a) Breeding Biology: monogamous and polygynous; nests solitary or semi-colonial (less than 50 m apart); nests on ground in rolling moorland, bracken-covered hills, peat bogs, new coniferous plantations with low, open canopy; favoured areas are used repeatedly over many years. Population trends in vole prey are reflected in the breeding success and possibly in the population levels of Hen Harriers. Egg laying occurs in May, so fieldwork should begin in April.

b) Census Methods: difficult to census because it often nests in remote areas of undisturbed moorland. Transect censuses and timed counts may provide useful indices of relative abundance, although foraging ranges overlap and are larger than the exclusively held nesting territories. Nest site censuses require watches from high vantage points for displaying birds between late March and late April, and for nest building up to mid-May; all suitable areas should be rechecked for missed nests in July. Frequent surveys should be undertaken initially, to establish normal range of variation in population size and to show whether changes in vole numbers are important.

c) Nest studies: courtship display flights by males and food-passes to the females reveal the location of nests, as does nest-building by the female. Observers must watch out for polygyny. After egg laying, females sit very tight, leave the nest to be fed by the male and tend not to return if watched by an observer who is not well-hidden or distant. After hatching, the female shows increasingly vigorous defence of the nest to man. After 2-3 weeks the brood disperses to within 3-4 m of the nest by day, returning to the nest to be fed, when cold, and at night; the brood is difficult to find at this period. Reproductive success of birds nesting in habitats other than heather moor can vary in relation to small mammal numbers (which show population cycling).

d) Population size: 300-400 pairs, but said to be declining because of persecution by game keepers. A national census by the RSPB has been undertaken in 1989. It is possible that populations cycle regularly in response to changes in vole numbers.

e) Current fieldwork:

Nest Record Scheme (1988): 124 nests.

Ringing Scheme (1987): 0 adults or juveniles; 149 pulli.

Estimate of total fieldwork in 1987 (assuming UK pop = 350 pairs):

i) No. of Nest Record Cards = 72, i.e.: c. 21% of British population.

ii) It is possible to calculate the probable maximum and minimum numbers of broods that were surveyed by ringers, given that 149 pulli were ringed. If mean fledged brood size = 0.9 per female present on territory in spring, then a probable maximum of 166 broods were surveyed by ringers (given that some would fail before ringing); if mean brood size was 3.1 per successful pair, then a probable minimum of 48 broods were ringed, i.e.: 14-47% of the British population were surveyed for ringing.

iii) Schedule 1 Licence Reports:
No. individual licence holders = 35 (37% through BTO)
No. nests visited = 115 (32% through BTO)
No. of other sites viewed from a distance or empty = 25 (24% through BTO).
Maximum proportion of British nests visited = 33%
Maximum proportion of British nest sites visited or viewed = 40%.
Twelve other sites were reported on Nest Record Cards without the need to hold a Schedule 1 Licence. So the maximum proportion of British nest sites visited or viewed = 43%.

f) Additional References: Petty & Anderson 1986, Picozzi 1978, Watson 1977.

6.2 Sparrowhawk

a) Breeding biology: monogamous, nests in trees in woodland, preferably coniferous; pairs tend to nest within a 50 m radius traditional site; pairs regularly spaced; males hunt in woodland over smaller range than females that hunt in open areas (e.g.: farmland); male territories are exclusive, female ranges overlap with other females.

b) Census methods: transect surveys unreliable because of extremely cryptic hunting behaviour, territorial dispersion, and habitat segregation of sexes. Nest-site censuses require very intensive, arduous searching through woodland, criss-crossing at 30 m intervals, beginning in April. Traditional nest areas can be

found in winter when vegetation cover is less dense; prey-plucking stumps are usually close to active nests; display flights occur too irregularly to be an efficient means of finding breeding pairs but they can be useful for identifying nesting areas if seen; variation in observer effort early in the season affects the efficiency of censuses, but such surveys by specialists are probably the only way to gain census data, albeit with less sensitivity than would be desired. Results from the BTO's CBC also provide an insensitive measure, but reveal trends when populations are below saturation level for the technique: since 1978 the CBC index has been fairly constant and probably represents a saturation level.
c) Nest studies: thorough nest searching requires the methods described in the previous section; nest visiting can be hazardous because it involves tree climbing and needs great care. Nestlings can be sexed at 12 days by weight.

d) Population size: 25,000 pairs; (Newton 1986) predicts a maximum possible population level of 32,000 pairs and 30,000 non-breeders in Britain. Populations have increased steadily since mid-1960s when many uses of organochlorine pesticides were banned or restricted.

e) Current fieldwork
Nest Record Scheme (1988): 237 nests (c. 1% of British population).
Ringing Scheme (1987): 440 adults or juveniles; 1268 pulli. (If it is assumed that 1.95 fledged young per female on territory in spring, then a maximum of 650 broods were surveyed for ringing; if it is assumed that 3.3 fledged young per successful pair, then c. 384 broods were ringed, i.e.: 1.5-2.6% of the British population was surveyed for ringing).

f) Additional References: Newton (1974, 1986, 1988).

6.3 Buzzard

a) Breeding biology: monogamous, occasionally bigamous; nests in trees or on crags in diversified habitats of woodland mixed with open farmland or moorland. Breeding dispersion can be clumped in areas of limited woodland, for birds that share their open-habitat ranges, or can be regularly spaced where birds defend home ranges; some territories are traditional. Soaring displays above territories depend on weather, occurring most often on fine breezy days between mid-morning and mid-afternoon, and can be given by breeding or non-breeding territorial pairs, intruding birds and by unmated birds.

b) Census methods: repeated transects or timed counts to count soaring birds in March and April could provide a useful estimate of relative abundance, providing that weather conditions were carefully assessed (this was used in the BTO Buzzard Survey of 1983); it would be useful if detailed work was undertaken to investigate the relationship between transect of soaring bird and density of breeding birds. Nest-site surveys are possible, but require intensive fieldwork, see below.

c) Nest studies: nests usually occur in a group within a 150 m radius area in the middle of a territory. Material is often added to nests each year and can be used by successive pairs. Nests are found by systematically searching woodland or crags; the approximate location of nests can be revealed by location of male's display dive; visits to all known nests in a territory should be made between mid-March and early April; breeding pairs may "decorate" up to three nests with fresh green material before laying in one of them, so thorough searching is necessary to ensure that the final nest has been found. If a nest with eggs was not found, then a search of the area should be undertaken again in July or August to locate noisy fledged young, audible up to 1 km distant. Observers must watch out for bigamy. Nests are often in trees or on crags that may be hazardous to climb. Reproductive success often varies in relation to vole numbers.

d) Population size: 12,000-15,000 pairs and apparently fairly static after an increase since numbers were depressed by organochlorine pesticide poisoning in early 1960s. It is still persecuted in some areas and may suffer from the effects of increasing afforestation.

e) Current fieldwork

Nest Record Scheme (1988): 140 nests (i.e. c. 1% of the British population).
Ringing Scheme (1987): 10 adults or juveniles: 200 pulli. (If fledged brood size from all nests is 1.37 then c. 146 broods were surveyed for ringing; if fledged brood size from successful nests is 1.9 then c. 105 broods were ringed; i.e. 0.8-1.1% of the British population were surveyed for ringing.

f) Additional References: Beklova & Pikula 1988; Fryer 1986; Picozzi & Weir 1974; Taylor et al. 1988; Tubbs 1972, 1974; Weir & Picozzi 1983.

6.4 Golden Eagle

a) Breeding biology; monogamous; uses traditional nest sites on crags or in trees, within exclusive territories in mountains or upland areas; within a territory, several alternative nest sites, 3-5 km apart, may be used in different years; nest-building behaviour occurs in winter and eggs are laid between March and May.

b) Census methods and Nest Studies: sites of the vast majority of home ranges are known; any new sites will be reported quickly within the bird-watching organisations and clubs unless in extremely remote areas; a complete annual census of all nest sites is impractical because of the remoteness of many sites and inaccessibility of many nests, but complete censuses should be undertaken every 10 years (repeating the 1982-83 national census: Dennis et al. 1984) to confirm the results from annual censuses of stratified subsamples of nests. Occupation of a territory can be confirmed by presence of recent pellets, moulted feathers and fresh food on eyries; confirmed occupation by a pair requires

observation of two eagles together or a nest with eggs or young. Unoccupied territories are difficult to confirm because of the need to visit all possible nesting sites. The full visiting schedule required for census and nest studies is: (1) January-early March, in good weather, to confirm occupancy; (2) late March to mid-April, observation of nest from a distance to confirm incubation; (3) mid April-early May, a quick visit to count eggs; (4) mid-May, a quick visit to count small chicks; (5) mid-June, visit to count (and ring) chicks; (6) late July-early August, to confirm fledging. For annual censuses and nest studies, a stratified sample of "annually checked" ranges should be checked each year, differentiated according to region and habitat or land-type because there are considerable regional differences in productivity.

c) Population size: c. 400 breeding pairs; very recently there appears to be some decline in the Eastern Highlands because increased deer culling results in less carrion (food) in winter. Golden Eagles still suffer from persecution and are adversely affected by increasing afforestation that decreases their hunting areas, and from improved sheep husbandry that reduces available carrion (Watson et al. 1987).

d) Current fieldwork:
Nest Record Scheme (1988): 16 nests (i.e. 4% of British population).
Ringing Scheme (1987): 0 adults or juveniles, 34 pulli.
Estimate of fieldwork in 1987:

i) No. of Nest Record Cards = 30, i.e. c. 7% of British population.

ii) If the average fledged brood size per pair found on territories in spring is 0.52, then 65 nests were surveyed for ringing. If the average fledged brood size per successful nest is 1.14, then 30 broods were ringed, i.e. c. 7-15% of the British population were surveyed for ringing.

iii) Schedule 1 Licence Reports:
No. individual licence holders = 43 (28% through BTO).
No. nests visited = 167 (16% through BTO).
No. other sites viewed from a distance or empty = 97 (5% through BTO).
Maximum proportion of British nests visited = 39%.
Maximum proportion of British nest sites visited or viewed = 62%.
Seven other sites were reported on Nest Record Cards without the need to hold a Schedule 1 Licence; thus the maximum proportion of British nest sites visited or viewed = 64%.

e) Additional References: Dennis et al. 1984, Watson et al. 1987.

6.5 Kestrel

a) Breeding biology: monogamous; breeds in traditional areas, but only the nest site is defended, the rest of the home range overlaps between neighbours; occurs in a wide range of habitats; nests in tree holes, ledges, buildings, old crow nests, on ground and in nestboxes; breeding displays include "V-flight" over nest site; forages by conspicuous hovering and perching on exposed positions; eggs are laid between April and June.

b) Census methods: road transect censuses are feasible and useful because of the visibility of hunting Kestrels (A. Village, pers. comm.); birds are equally visible in all months except during incubation and brooding, when females are seldom seen; no. of Kestrels per km is correlated with breeding densities found by less biased but more laborious methods; results are habitat-specific, because habitat structure affects visibility; calibration investigations are required to compare different habitats. An alternative method for estimating relative abundance is to monitor the occupancy rates of a "annually checked" sample of nestboxes. Annual censuses are required because numbers vary considerably in relation to vole numbers in rural areas and to bird numbers in urban areas.

c) Nest studies: all woods, isolated trees and crags, must be thoroughly searched in spring to find all nest-sites; display flights can help to reveal sites: tree or rock climbing to reach nests may be hazardous. Breeding success varies considerably in relation to vole numbers in rural areas; the normal range of variation needs to be measured.

d) Population size: 30,000-80,000 pairs; stable or slightly declining.

e) Current fieldwork:

Nest Record Scheme (1988): 365 nests (i.e.: 0.5-1.2% of British Population).
Ringing Scheme (1987): 152 adults or juveniles; 1324 pulli. (If the mean fledged brood size per breeding pair is 2.50 then 530 broods were surveyed for ringing; if the mean brood size per successful pair is 3.75 then 393 broods were ringed; i.e. 0.4-1.8% of British population were surveyed for ringing.

f) Additional References: Village 1982, 1983, 1984, 1990.

6.6 Merlins

a) Breeding biology: monogamous; nests on ground, in crow nests in trees or on crags; on high moorland, fell bog and grouse moors but avoiding large stands of trees; nest areas are often traditionally used, but nest sites may move by up to 100 m between years; displays are inconspicuous.

b) Census methods and nest studies: transects are not useful for this sparsely distributed, fast-moving raptor because it is very

easily missed, but timed counts may be feasible. Nest-site surveys require intensive fieldwork by specialists. Visits to breeding areas in autumn and winter are useful for finding signs of nesting; visits should be made in April to establish territory occupancy, by watching from vantage points; site occupation is also revealed from droppings, pellets and especially pluckings. Knowledge of an area takes several years to build up, but is necessary to make an accurate estimate of density. Nest sites should be visited in May to record clutch sizes; late June or July for nestlings which are often very noisy and relatively easy to locate (good for locating pairs that were missed earlier in the season); when a nest fails but adults remain on territory searches for repeat clutches should be made. Age of male can be assessed from plumage: brown-backed for yearlings, blue-grey backed for two years or older.

c) Population size: 550-650 pairs; but populations declining possibly because of declines of heather moor managed for grouse, and increases in sheep grazing and afforestation; declines in the control of avian and mammalian predators by gamekeepers may be a factor, as well as increases in human disturbance.

d) Current Fieldwork: (assuming a British population of 600 pairs).

Nest record Scheme (1988): 194 nests (i.e.: 32% of British population).
Ringing Scheme (1987): 16 adults or juveniles; 668 pulli.
Estimate of fieldwork in 1987:

i) No. of Nest Record Cards = 127, i.e. 21% of British population.

ii) If the average size of fledged broods per pair is 1.70-2.40, depending on food supplies, then 278-393 nests were surveyed for ringing; if the mean size of fledged broods per successful pair is 2.92-3.60, then 186-229 broods were ringed; i.e.: 31-66% of the British population were surveyed for ringing.

iii) Schedule 1 Licence Reports:
No. individual licence holders = 99 (40% through BTO).
No. nests visited = 477 (36% through BTO).
No. other sites viewed from a distance or empty = 181 (21% through BTO).
Max. proportion of British nests visited = 80%.
Max. proportion of British nests visited or viewed = 109%
Thirty-nine other sites were recorded on Nest Record Cards without need to hold a Schedule 1 Licence, thus the maximum proportion of British nest sites visited or viewed = 116% (i.e.: 697 sites).

iv) The result in (c) appears to suggest that there are more nest sites studied than the maximum population estimate. Bibby and Nattrass (1986) give a regional breakdown of the Merlin population in Britain. Comparison of their results with Schedule 1 Licence returns shows close agreement for all but two regions (a) in Shetland, Bibby and Nattrass

give the Merlin population as 20 pairs, but Schedule 1 Licence returns show 80 nests being visited; (b) in Scotland, North of the Great Glen, Bibby and Nattrass estimate c. 100 pairs (which may well be a considerable underestimate), but there were only 21 nests visited by Schedule 1 Licence holders. Overall, this would suggest that an extremely high proportion (60-80%) of nests are visited annually in all areas except North of the Great Glen.

e) Additional References: Bibby 1986; Bibby & Nattrass 1986; Haworth & Fielding 1988; Meek 1988; Newton et al. 1978, 1986; Roberts & Green 1983.

6.7 Peregrine

a) Breeding Biology: monogamous; nests in traditional sites on crags and cliffs, although expanding populations in Britain are beginning to use unusual new sites such as the ground, trees, buildings and quarries; single birds take temporary territories; display flights are given near nest sites; 2-4 alternative sites (2-3 km apart although sometimes much further) can be used in different years within a territory.

b) Census methods and nest studies: Transect censuses are unsuitable; nest site surveys are hard because of the inaccessibility of many nests and the remoteness of some major nesting areas. New nest sites are difficult to find, but are probably reported to County Recorders on the margins of its national distribution. National surveys were undertaken in 1961, 1971 and 1981, in which the majority of historically known and currently used sites were checked; it would be most desirable to repeat these complete National surveys at ten-year intervals and , in fact, the next census is planned for 1991. Estimates of relative abundance could be made by checking the occupancy rates of stratified sample of core sites in different habitats and regions. Pre-breeding visits in April reveal territory occupation from the presence of birds at or near a site; visits in May and June should be made to observe clutch size and hatching success and in July and August to observe fledging success.

c) Population size: 900 pairs; increasing because of decreasing levels of organochlorine pesticide pollution and reduced persecution.

d) Current Fieldwork:

Nest Record Scheme (1988): 103 nests (i.e.: 11% of British Population).
Ringing Scheme (1987): 3 adults or juveniles; 375 pulli.
Estimates of fieldwork in 1986:

i) No. of Nest Record Cards = 107 nests (i.e.: 12% of British population).

ii) 294 pulli were ringed; if the average size of fledged broods per territorial pair is 1.07 then 275 nests were surveyed for ringing; if average size of fledged broods per successful pair is 2.19, then 134 broods were ringed; i.e.: 15-33% of the British population were surveyed for ringing.

iii) Schedule 1 Licence Reports:
No. of individual licence holders = 151 (22% through BTO).
No. of nests visited = 692 (16% through BTO).
No. of other sites viewed from a distance or empty = 139 (22% through BTO).
Maximum proportion of British nests visited = 77%.
Maximum proportion of British nests visited or viewed = 92%.
Twenty-four other sites were recorded on Nest Record Cards without need to hold a Schedule 1 Licence, thus the maximum proportion of British nest visited or viewed = 95% (i.e.: 854 nests).

iv) Comparison of Schedule 1 reports with data from Ratcliffe (1984) suggests that significant multiple-recording occurs in Northern England and Southern Scotland, but under-recording occurs in Wales and the Highlands. It is probable that approximately 65% of nest sites are visited or viewed in Britain annually.

e) Additional References: Ratcliffe 1980, 1984.

6.8 Hobby

a) Breeding Biology: trans-Saharan migrant; monogamous; breeds on dry heath, downland, mixed farmland; nests in old crow nests usually in Scots Pine Pinus sylvestris; some sites are used traditionally; displays are unobtrusive and foraging behaviour is secretive and fleeting.

b) Census methods and nest studies: transect censuses are unsuitable and nest site surveys require very intensive fieldwork. It is probably much overlooked in farmland and a collation of all sightings from County Bird Reports and active ornithologists (especially BTO members) would help to assess distribution. Birds can be located in early May and June by spending many hours in field checking suitable trees for nests, or by scanning for displaying, soaring and hunting birds and flying young. Birds are very secretive during incubation and they disperse quickly after failure. Successful nests that were missed early in the season can be found by listening for noisy young and because family parties remain within 0.75 km of their nests for about a week after fledging.

c) Population size: 300 pairs; although Fuller et al. (1985) consider that Hobbys are much overlooked in farmland and that there could be up to 1000 pairs in Britain.

d) Current Fieldwork: (Assuming 300 pairs in Britain).

Nest Record Scheme (1988): 27 nests (i.e.: 9% of British population).
Ringing Scheme (1987): 1 adult or juvenile; 30 pulli.
Estimates of fieldwork in 1986:

i) No. of Nest Record Cards = 32 (i.e.: 11% of British population).

ii) 53 pulli were ringed; if the average size of fledged broods per pair is 1.6 then 33 nests were surveyed for ringing; if the average size of successfully fledged broods is 2.3, then 23 broods were ringed; i.e.: 8-11% of the British population.

iii) Schedule 1 Licence Reports:
No. of individual licence holders = 14 (93% through BTO).
No. of nests visited = 34 (97% through BTO). No. of other sites viewed = 0. Maximum proportion of British nest visited = 11%.
6 other sites were recorded on Nest Record Cards without need to hold a Schedule 1 License, thus the maximum proportion of British nests visited = 13%.

e) Additional References: Fiuczynski & Nethersole-Thompson 1980; Fuller et al. 1985; Parr 1985.

6.9 Barn Owl

a) Breeding Biology: generally monogamous; occupies wide variety of grassland habitats from upland sheepwalk to lowland farmland. Solitary cavity nester, will take readily to artificial nestboxes. Most vocal in early spring, 'screeching' male advertises territory. Very quiet at other times of year. Short-term population dynamics strongly affected by abundance of main food item, the field vole; large fluctuations in both numbers and breeding success.

b) Census methods: a working group on the BTO owls project decided the only practical way to obtain reliable data was to carry out thorough nest-searches to locate all sites within a defined area. This was carried out in 1989 in a target sample of 25 10-km squares. Choice of area is obviously very important: it must cover both high and low-densities of Barn Owls. Censusing of solely 'good' habitat could mask much of the short-term population change. Trials of call-playback have been tried in several areas. The technique can give useful results, sometimes quickly locating breeding pairs, but is not reliable enough to use as the sole census method - many birds showed no response at all. Previous local and national surveys (notably by Shawyer 1987) may well present unreliable results because natural population fluctuations in response to small mammal numbers have not been taken sufficiently into account and because Barn Owls are often overlooked unless searched for intensively (Taylor et al. 1988; J. Cayford, pers. comm.).

c) Nest studies: this species is well-suited to nest studies, provided the sampling of nest-sites has been carefully considered to avoid bias to 'good' areas (for the same reasons as mentioned above). It is generally tolerant of regular nest-visiting, and adults can be caught safely at the nest (with care - a 'code of conduct' is currently being prepared), thus enhancing the quality of the information that can be obtained. A detailed nest recording scheme was begun under the BTO Owls project during 1988 and 1989 for both this species and the Tawny Owl. Measurements of eggs and chicks were taken during each visit, enabling accurate assessment of the age of the nest and of chick body condition. Standard egg density curves (to predict hatching date and plan future visits) and chick growth curves are now available. The long fledging period of the Barn Owl (around 52 days) can cause some problems to estimating fledging success as some birds will leave the nest temporarily before this time. If the data are of sufficiently high quality and observers are aware of this behaviour, this factor can be taken into account during analysis.

d) Population size: 4,400 pairs in Britain and Ireland; this should be treated as a crude estimate because it does not take into account short-term changes. A population can, for example, increase by more than 100% across a single vole cycle, highlighting the need for detailed long-term monitoring. The Owl's population level has apparently declined by about 50% since the 1930s and the reasons for this are complex and unclear although habitat loss, especially of rough grassland, and loss of traditional nest sites are implicated.

e) Current fieldwork:

Nest Record Scheme (1988): 236 nests (generally high vole year); (i.e: 5.4% of British population); average over last 3 years is 162; i.e.: c. 4% of the British population.
Ringing Scheme: 83 adults or juveniles, 1033 pulli in 1988, and the last 3-year average: 60 adults or juveniles, 679 pulli). If the average size of successfully fledged broods = 2.5, then young at 272 nests were ringed (ie: c. 4% of the British population).
There are many current local Barn Owl projects. Particular ones of note are Iain Taylor's (Edinburgh University) long-term (begun in 1978) study in SW Scotland (partly funded by NCC) and the newly started RSPB work in Suffolk. Also many amateur groups.
f) Additional References: Taylor et al. (1988), Shawyer (1987), Percival (1990).

6.10 Tawny Owl

a) Breeding biology: monogamous and site-faithful through year; occupies a wide variety of woodland and farmland habitats. A solitary cavity-nester which takes readily to nestboxes. There are two peaks of vocality: in the autumn when juvenile birds establish their territories, and in the early spring coinciding with courtship. Fledged young are readily detectable by voice in mid-late summer. Population dynamics are affected by small mammal abundance, but not in such a marked way as the Barn Owl: in years of low food supply many birds opt out of breeding completely but

the overall population remains fairly stable as there is density-dependent recruitment into the adult population (Southern 1970).

b) Census methods: the Tawny Owl is well-suited to either territory-mapping or point count censusing, being a highly vocal territorial species. The relative benefits of either of these two methods depends on the aim of the monitoring: point counts can provide a rapid technique for covering a large area (and as such was chosen for the 1989 BTO Tawny Owl survey) but do not provide such detailed information as the territory mapping which is much more labour-intensive. Tawny Owls respond well to call-playback when this is used carefully.

c) Nest studies: takes readily to nestboxes, but part of any study population may nest in natural sites in tree-holes or on the ground, such nests are relatively difficult to find. Tolerant of both nest-visiting and the catching of adults at the nest is safest from a week after hatching (see notes under Barn Owl and in Percival (1988, 1990) for further details of the BTO Owls Project nest recording scheme.

d) Population size: probably the commonest British bird of prey, though no specific survey has ever been carried out to assess its abundance. The last Breeding Atlas estimated the population to be between 10,000 and 100,000 pairs and there is no evidence of any major changes since then.

e) Current fieldwork:

Nest Record Scheme (1988): 361 nests (3-year average = 281); i.e.: c. 1% of the British population).
Ringing Scheme (1988): 185 adults or juveniles and 1192 pulli, and the last three-year average: 142 adults or juveniles and 882 pulli. If the average size of successfully fledged broods = 1.5, then young from 588 nests were ringed (ie: c. 5% of the British population.
The only current professional study of the Tawny Owl is Steve Petty's work in SW Scotland and NE England (for Forestry Commission) (Petty 1987). There are many local amateur groups working on this species.

f) Additional References: Southern (1970), Hirons (1985).

6.11 Short-eared Owl

a) Breeding biology: monogamous, occasionally bigamous; prefers remote open country: moor, heath, new plantations, rough grazing, marsh, bog, sand-dunes, islands; solitary nesters, on ground, male establishes territory and attracts females by conspicuous display flights in early morning, late evening; calls are also given; population densities and reproductive success affected by vole numbers in grassland; in heather areas the pigmy shrew is most important part of diet and shows little variation in population size.

b) Census methods: transect censuses or timed counts may be successful; call-playback could usefully be tested; nest-site surveys are difficult (see below) and should be used only if other methods do not succeed or are not feasible.

c) Nest studies: nests are difficult to find at egg stage because females sit very tightly on eggs, and males are very sensitive to observers when bringing food to nest; nest defence increases as nesting progresses, but the response of individual pairs is very variable: females may or may not sit tight, males may or may not give nest position away by distraction displays and may or may not attack intruders. To find nest sites requires systematic ground searching. After hatching, the increasing rate of nest provisioning by the male reveals nest sites. Fledging success is difficult to estimate because nestlings leave the nest before they can fly and remain within 50-200 m of nests.

d) Population size: very little known, perhaps 1000 pairs in poor vole years.

e) Current fieldwork:

Nest Record Scheme (1988): 29 nests.
Ringing Scheme (1987): 4 adults or juveniles; 92 pulli (if mean brood size at fledging from successful nests is 3.76, then 24 broods were ringed).

f) Additional References: Lockie (1955), Roberts & Bowman (1986).

6.12 Long-eared Owl

a) Breeding biology: monogamous; uses corvid, Woodpigeon and Sparrowhawk nests in coniferous woods, plantations or small isolated groups of trees on heath, moor and farmland; solitary, territorial nesters; probably site-faithful; population density and reproductive success affected by vole numbers; territories are established in February and March by triple-hoot calls at dusk as well as by display flights.

b) Census methods: transect, point, or timed counts in spring to listen for calls could be successful; playback of calls should be tested as a method; nest site surveys are difficult (see below). Casual observations from County Bird Reports or from active ornithologists (e.g: BTO members) would be useful for establishing the distribution of this species.

c) Nest studies: all woods should be checked regularly for signs of occupation from early March; dropping, pellets, scraps in host nests; extensive rechecking for a nest should be made if a pair is regularly flushed from a wood; missed nests can be found later in season from the calls of the young, but a few nests that fail early can be missed. Young leave the nest 7-10 days before fledging.

d) Population size: very little known; 3-10,000 pairs; numbers are said to have decreased since 1900 due to competition from Tawny Owls.

e) Current fieldwork:

Nest Record Scheme (1988): 31 nests.
Ringing Scheme (1987): 59 adults or juveniles; 31 pulli; (if 1.7 young are fledged per nesting pair, then 18 broods were surveyed for ringing; if 3.2 young are fledged from successful nests than 10 brood were ringed).
f) Additional References: Glue 1977, Village 1981.

6.13 Little Owl

a) Breeding biology: monogamous; breeds in well-timbered agricultural areas and parkland; nests in holes in old deciduous trees, especially in hedgerows; site-tenacity is strong; perches prominently near nest sites; main territorial calling-period is March; solitary, territorial nester; main activity period is dawn and dusk.

b) Census method: transect, point or timed counts in March to listen for calls could be successful, as might call-playback and mapping censuses; nest site surveys are unlikely to be feasible because of the often high densities of potential nest sites in areas of suitable habitat.

c) Nest studies: being tree-hole nesters, there may be difficulty in gaining access to some nesting chambers; nests can be found by observing behaviour of territorial pairs.

d) Population size: 7-14,000 pairs; introduced in late 19th Century; decreases in cold winters.

e) Current fieldwork:

Nest Record Scheme (1988): 48 nests.
Ringing Scheme (1987): 84 adults or juveniles; 1023 pulli (if the average brood size at successful nests is 2.40, then 426 broods were ringed).
f) Additional References: Glue & Scott 1980.

6.14 Raven

a) Breeding biology: monogamous; occurs in open mountainous and coastal regions; solitary and territorial; with two or more alternative nest sites on cliff ledges; with an overhang above, or in trees; territories are regularly dispersed and are often traditionally used; lays in late February to early March; non-breeders often gather in groups.

b) Census methods and Nest studies: too widely dispersed for transects to be useful. Territories can be considered occupied if displaying birds, an alarmed adult or a pair are regularly seen in

breeding habitats or if a nest has been newly built or lined; nests are often inaccessible so nesting can be presumed successful if the site is covered with excreta whitewash in May or presumed a failure if not or if the wool lining has been pulled out over the rim of the nest; success is considered confirmed if fledglings are seen or if a brood is less than one week from fledging in a nest which is too remote or inaccessible to be visited again by the recorder.

c) Population size: possibly 5000 pairs; but is decreasing due to persecution, due to better sheep husbandry that produces less carrion and possibly due to increasing upland afforestation.

e) Current fieldwork:

Nest Record Scheme (1988): 151 nests; i.e.: c. 3% of British population.
Ringing Scheme (1987): 7 adults or juveniles; 395 pulli; (If fledged brood size per successful nest = 2.6 - 3.19, thus a minimum of 124-152 nests were ringed; if fledged brood size per territorial pair is 1.5-1.9, then a maximum of 208-263 nests were surveyed for ringing); i.e.: c. 2.5 - 5.3% of the British population.

f) Additional References: Dare 1986; Ewins et al. 1986; Goodwin 1986.

6.15 Summary (see Table 6.1)

(1) Census methods:

(a) Species that could be censused using transects, point or timed counts, (with or without call playback): Hen Harrier, Buzzard, Kestrel, Short-eared Owl, Long-eared Owl, Tawny Owl (also territory mapping), Little Owl.

(b) Species that require nest-site censuses by intensive fieldwork: Golden Eagle, Merlin, Peregrine, Barn Owl, Raven and possibly Hen Harrier.

(c) Species that are extremely difficult to census accurately except by very intensive fieldwork: Sparrowhawk, Hobby.

(2) Nest studies: all require intensive fieldwork by specialists: Kestrels, Barn Owls, Tawny Owls, Little Owls and Long-eared Owls can be studied in nestboxes.

(3) Current fieldwork coverage for nest studies: (N.B. Rates of nest visiting per nest are generally low and need to be increased for all species; confirmation of adequacy of coverage, both nationally and with respect to regional or land-type divisions, must await completion of consisting analyses in phase 2 of this project).

(a) Adequate because (1) more than 100 nests and more than 30% of British population is monitored: Hen Harrier, Golden Eagle; or (2) more than 250 nests are monitored: Sparrowhawk, Kestrel, Merlin, Peregrine, Tawny Owl and Little Owl.

(b) Should be improved because 100-250 nests are monitored: Buzzard, Barn Owl and Raven.

(c) Need a lot more work because less than 100 nests are monitored: Hobby, Short-eared Owl, Long-eared Owl.

(4) Species that are affected by cyclic vole populations and will require frequent monitoring to assess the normal range of variation; trends of increase or decrease can be revealed only over periods of 10-15 years unless concurrent monitoring of small mammal populations were encouraged too: Kestrel, Barn Owl, Tawny Owl, Short-eared Owl, Long-eared Owl and possibly Hen Harrier and Buzzard.

Table 6.1 Summary of suitable census methods, current population sizes and estimates of the number of nests visited annually for species to be included in a NRMS.

SPECIES	CENSUS METHOD*	BRITISH POPULATION	No. NESTS VISITED ANNUALLY
Hen Harrier	Tr, TC, I	300-400	100-150
Sparrowhawk	I	25000-30000	400-600
Buzzard	Tr, TC	12000-15000	100-200
Golden Eagle	O, I	400-450	150-200
Kestrel	Tr, TC, O	30000-80000	400-500
Merlin	I	550-650	200-300
Peregrine	O, I	900-1000	300-500
Hobby	I	300-1000	30-40
Barn Owl	I	3000-5000	150-200
Tawny Owl	PC, M, O	20000-40000	200-400
Short-eared Owl	Tr, TC, I	1000?	20-30
Long-eared Owl	PC, O	3000-10000	30-40
Little Owl	Tr, PC, TC	7000-14000	200-400
Raven	I	5000?	150-300

* Census Methods:
I = Intensive nest searches
M = Territory Mapping
O = Occupation rates of traditional or nestbox sites
PC = Point Counts
TC = Timed Counts
Tr = Transect censuses

7. CONCLUSIONS

The main requirements for a National Raptor Monitoring Scheme (NRMS) are: (1) to obtain accurate information on changes in population size, distribution, breeding success and survival rates of the 14 species discussed in section 6 of this report; and (2) that such a scheme should enlist the cooperation of amateur and professional raptor specialists who would provide data in return for useful feedback and analysis, thereby ensuring (3) a relatively low cost.

A NRMS will only be successful if it is effective in collaboration, coordination, methodological development, analysis and administration.

7.1 Collaboration

The organisations actively involved in long-term monitoring of raptor populations in Britain are BTO, RSPB, NCC, ITE, Hawk and Owl Trust and Raptor Study Group (RSGs). All are already collaborating with each other over various aspects of their work and thus collaboration within an NRMS is feasible. It should be noted that all have certain proprietorial interests over certain sets of data and that collaboration will need to be negotiated with care.

a) The BTO: runs the Nest Record Scheme and the Ringing Scheme and has proven experience in analysing such data to calculate breeding success and survival rates. It runs the Raptor Research Register that records the majority of raptor work in Britain. One of the main functions of the BTO is to organise membership-based population censuses: it has the infrastructure to run the surveys that would be required by a NRMS.

b) The RSPB: has put much effort into protecting rare raptors in the U.K. It obtains much information from their wardens and collates information from the RSGs. It is keen to see the development of a NRMS. However, it is keen to collect site information on rare raptors and has built up an excellent rapport with RSGs. There would be a case for the RSPB to continue to collect information from certain sources, before passing it on to a NRMS. If the NRMS passed useful site information back to the RSPB then the RSPB might be encouraged to contribute nest records collected by their wardens, for analysis within a NRMS.

c) The NCC: gains a potentially large amount of information on Schedule 1 raptors from Licence Report Forms. Part of this work is contracted out to BTO and RSPB. The new Licensing Officer (after discussion with HQPC in Sept. 1989) has made steps to improve the quantity and quality of information that come from RSGs, by arranging for them to vet any applications to disturb nesting Schedule 1 raptors in their study populations before approval.

Further increases in the quality and quantity of information that comes to the NCC could be achieved by changing the design of the Licence Report Form to become a detailed site record of visits

made to nests (as described in Section 3) or by asking for BTO Nest Record Cards to be submitted together with a brief summary of nests visited. The increase in information thereby gathered would be of immense value to conservation and as a contribution to a NRMS. Information from such forms would have to be kept secure and released only on a "need-to-know" basis; thus ensuring full confidence of recorders.

The NCC also funds short-term specialist projects by its own staff and by those of ITE and Universities and it contracts the BTO to produce information from Ringing and Nest Record Schemes. Although some NCC regional staff and wardens are involved in raptor monitoring at a local level, many more could contribute valuable information to a NRMS if they were required to complete redesigned Schedule 1 Licence forms; up until recently they were not required to return report forms.

d) ITE, Universities and Forestry Commission: the specialist raptor ecologists in these organisations may not be willing to contribute data from intensive studies to a NRMS because their data would be of a very high quality, obtained for their own research. It would be very useful to persuade such professional scientists to allow their data to be compared with NRMS data to assess the reliability of the latter. With the possibility of joint publications such scientists could be willing to cooperate on work that would give their local studies a national perspective.

e) Hawk and Owl Trust: this has developed a good national network of contacts of people interested in Barn Owls especially and is developing more to do with other raptors. It is primarily concerned with promoting raptor conservation through projects such as nestbox provision or studies of feeding and nesting requirements of raptors. The Trust has useful links with NCC, BTO, RSPB and Forestry Commission and would be likely to contribute information to an NRMS.

f) RSGs: The majority of RSGs already send much of their data to BTO, RSPB and NCC, but can be reluctant to release accurate site-location details. They have a general keenness to see their data being analysed and used as usefully as possible, but data on rare species would have to be kept secure and extra administrative demands on them should be kept to a minimum. If a NRMS was able to take on some of the administration (i.e.: data circulation) and provide some finances to cover photocopying and postage expenses, the response of RSGs would probably be favourable. Their work is entirely voluntary, although modest support for expenses is given by NCC in some cases, so careful negotiations and liaison are required to ensure their cooperation. Trust in a NRMS may take some time to build up.

7.2 Coordination

The efficient coordination of data gathering requires standardised techniques and recording forms. In particular a design for a standardised "site record form" should be agreed by all major recording organisations for gathering breeding data.

There is a good case for such a form to be used in reporting the use of Schedule 1 Licences; but this would have to be introduced with care to avoid antagonising raptor workers, who are often suspicious of bureaucracy.

A central coordinator should develop sampling strategies for site-recording, such that useful stratification according to geographical region and habitat (at least) is achieved. Coordination between groups should aim to produce a list of "annually checked" nest sites that are checked each year (for species with traditional sites). With the cooperation of RSGs, such "annually checked" sites could be taken over by new observers as older ones drop out.

A major aim of a NRMS should be to provide the development of RSGs in England and Wales. The BTO would best be able to undertake such work through its membership. The NCC and RSPB may be interested in coordinating data gathering for rare or endangered species.

An essential part of the successful maintenance of a NRMS would be to develop systems to feedback information to contributors. New details of basic breeding biology would help increase the effectiveness of fieldworkers. Particularly useful would be the feedback of graphs of egg-density and nestling-growth changes that could be used for accurate ageing of nest contents. An annual or six monthly newsletter would be essential for exchanging information between groups, for coordinating surveys and for reporting results. These aims have been well satisfied by the Owl Study Group Newsletter created by SMP to support the BTO Owls Project. This Newsletter consists of 5 pages of A4 size, mailed twice a year to owl research workers and enthusiasts. It should be very easy to convert this into a Raptor and Owl Study Group Newsletter to service a NRMS.

One further form of feedback to contributors would be an annual meeting. It could form part of another organisation's conference and would be useful as a forum for exchanging ideas and experiences and for promoting cohesion within the group's members.

7.3 Methodological Development.

Much census work for raptors needs to be tested and validated, particularly the usefulness of transects, point counts and the use of call-playback. An important task for the NRMS initially, will be to develop techniques and assess their accuracy and sensitivity.

7.4 Data analysis

Data analysis for a NRMS is likely to require the development of new techniques given that new survey techniques will be developed and that raptors, with their deferred breeding, asynchronous hatching and variable fledging periods, are quite

different to passerines and waterfowl on which was most large scale population studies have been undertaken in the past. Data will have to be input on computer, some should be able to be input using an optical mark reader. Security will have to be high to protect location details and to maintain the trust of fieldworkers.

Analysis should be undertaken efficiently and quickly, so that results can be produced before the next field season. The development of population dynamics models for species that are well covered by NRMS surveys may take time, but work already underway in BTO and ITE would usefully contribute to such analysis.

7.5 Products

A NRMS should produce an annual report detailing changes in population level indices, breeding productivity and survival for the raptors covered in this report. Results of special census surveys should be published in scientific journals.

Each year, one or possibly two newsletters should be sent to all participants to provide feedback of information and results from previous years' work and giving details of fieldwork planned and being promoted for the current year.

7.6 Administration and funding:

A full time organiser would be required who would:

(1) negotiate collaboration of interested parties, involving substantial amounts of travel around the country (especially to attend Raptor Study Group meetings);
(2) develop census and other methodology, involving fieldwork for 4-6 months each year;
(3) undertake data analysis; and
(4) organise newsletters and meetings.

Clerical staff would be required to administer mailing of recording forms, newsletters etc., to reply to routine enquiries and to input data to the computer. Funding would be required to cover the cost of staffing, stationary (including data-sheets), postage, and newsletter production within the NRMS coordination body. Funds to allow the meeting a steering group of representatives of interested parties would be required.

Extra funds to cover postage and photocopying within RSGs would probably be very beneficial, but contribution to travel costs are probably unnecessary and may even act as a disincentive to amateurs that value their independence, or if such funding was ever curtailed. Full rebates on raptor rings would be very important for successful work on survival. Some financial contributions may be beneficial for the encouragement of small mammal surveys by the members of the Mammal Society.

An example breakdown of the annual costs of a NRMS is given below using costings provided by Dr D. Hill, Director of Development at the BTO.

1) Full-time Organizer (Higher Scientific Officer Grade; including secretarial services, BTO computer time, administrative overheads, fieldwork travel, subsistence and equipment (eg: ropes), tree-climbing course, maps, etc.)	£36,531
2) Project Supervisor (Senior S.O: 30 days)	£ 5,467
3) Half-time Clerical Assistant (Assistant Scientific Officer Grade; including administrative overheads, BTO computer time)	£14,951
4) Travel and subsistence (to collaborating bodies)	£ 1,000
5) Newsletter production and postage	£ 400
6) Recording Form production and postage	£ 300
7) Support for Raptor Study Groups (10-15 groups @ £50/group)	£ 750
8) Full rebate on raptor rings (current levels of use)	£ 2,500
TOTAL	£61,899

Capital expenses:

Binoculars and Telescope for fieldwork	£ 500
PC Computer and printer with software	£ 2,200
Vehicle (4 wheel-drive)	£15,000
TOTAL	£17,700

7.7 Summary

(1) A National Raptor Monitoring Scheme is feasible because interested bodies already collaborate and it is possible to collect the data required for most species.

(2) Further collaboration will be achieved only if the interests and sensitivities of contributing bodies are recognised.

(3) Efficient coordination of a NRMS requires development of a "site record form", stratified samples of nest sites that are checked each year, the development of Raptor Study Groups in England and Wales, and the rapid feedback of information to contributors before the next season begins.

(4) Much methodological work on census techniques must be undertaken initially.

(5) Full development of a NRMS requires a full-time scientific coordinator and clerical staff for general administration and data input. Extra funds may be required to ease the cost of administration within amateur RSGs, to encourage

8. ACKNOWLEDGEMENTS

The production of this report has benefited greatly from guidance and comments from M.W. Pienkowski. Much valuable information and ideas came from conversations with Kevin Baker, Leo Batten, Colin Bibby, Eric Bignal, Roger Broad, Keith Brockie, John Cayford, Peter Clement, Roy Dennis, Dave Dick, Tim Dix, Ron Downing, David Glue, Graham Elliott, Brian Etheridge, J.R.Flowerdew, Colin Galbraith, Alan Heavisides, David Hill, Peter Lack, Brian Little, Mick Marquiss, John Marchant, Ian Newton, Sandy Payne, Richard Porter, Derek Ratcliffe, Gordon Riddle, Dick Roxburgh, Colin Shawyer, Don Smith, Patrick Stirling-Aird, David Stroud, Bob Swann, Patrick Thompson, Andy Village, Adam Watson and Jeff Watson. Much needed hospitality was gratefully received from Graham Pierce, Jim Reid and Don Smith in Scotland. Finally, we are very grateful for the excellent typing of Jane Wills and Tracey Jarvis for their amazing abilities to decipher our scrawl and to Liz Murray for drawing Figure 5.1.

HQPC's and SRB's work on this project was funded by the NCC.

9. REFERENCES

Anderson, D.R., Burnham, K.P. & White, G.C. (1985) Problems in estimating age-specific survival rates from recovery data of birds ringed as young. J. Anim. Ecol. 54: 89-98.

Beklova, M & Pikula, J. (1988) The ecological, quantitative distribution of Buteo buteo in Czechoslovakia. Folia Zoologika 37: 241-254.

Bibby, C.J. (1986) Merlins in Wales: Site occupancy and breeding in relation to vegetation. J. Appl. Ecol. 23: 1-12.

Bibby, C.J. & Nattrass, M. (1986) Breeding status of the Merlin in Britain. Brit. Birds 79: 170-185.

Bignal, E.M., Curtis, D.J. & Mathews, J.L. 1988) Islay: Land types, bird habitats and nature conservation. Part 3: The potential of remote censusing for land use mapping: a pilot study on Islay. NCC Chief Scientist's Directorate. Report No. 809, Part 3.

British Trust for Ornithology (1989) Nest Record News, No. 5. BTO, Tring.

Brown, A.W.A. (1978) Ecology of pesticides. Wiley, New York.

Brown, L.H. (1976) British birds of prey. Collins, London.

Brownie, C. Anderson, D.R., Burnham, K.P. & Robson, D.S. (1985) Statistical Inference from Bird Recovery Data - A Handbook. United States Department of the Interior Fish and Wildlife Service Resource Publication No. 156, Washington.

Buckland, S.T. (1982) A mark-recapture survival analysis. J. Anim. Ecol. 51: 833-847.

Buckland, S.T. (1987) On the variable circular plot method of estimating animal density. Biometrics 43: 363-384.

Buckland, S.T. & Baillie, S.R (1987) Estimating bird survival rates from organised mist-netting programmes. Acta Ornithologica 23: 89-100.

Burnham, K.P. (in press) Survival analysis of recovery data from birds ringed as young: efficiency of analyses when numbers ringed are not known. in Proceedings of 1989 EURING Conference. The Ring.

Burnham, K.P. & Anderson, D.R. (1979) The composite dynamic method as evidence for age-specific waterfowl mortality. J. Wildl. Mgmt. 43: 356-366.

Burnham, K.P., Anderson, D.R. & Laake, J.L. (1980) Estimation of density from line transect sampling of biological populations. Wildlife Monogr. 72.

Cadbury, C.J. (1980) Silent Death. RSPB, Sandy.

Cadbury, C.J. (1988) Birds of prey. Conservation Information leaflet. R.S.P.B., Sandy.

Cadbury, C.J., Elliott, G. & Harbard, P. (1988) Birds of prey conservation in the U.K. RSPB Conserv. Rev. 2: 9-16.

Charles, W.N. (1981) The abundance of the field vole Microtus agrestis in conifer plantations. Pages in F.T. Last & A.S. Gardiner, eds. Forest and Woodland Ecology. ITE, Cambridge.

Clobert, J., Lebreton, J.D. & Allaine, D. (1987) A general approach to survival rate estimation by recaptures or resightings of marked birds. Ardea 75: 133-142.

Conroy, M.J. & Williams, B.K. (1984) A general methodology for maximum likelihood inference from band-recovery data. Biometrics 40: 739-748.

Cooke, A.S., Bell, A.A. & Haas, M.B. (1982) Predatory birds, pesticides and pollution. I.T.E., Cambridge.

Cramp, S. (1980) The birds of the western Palearctic. II Hawks to Bustards. O.U.P., Oxford.

Cramp, S, (1985) The birds of the western Palearctic. IV Terns to Woodpeckers. O.U.P., Oxford.

Dare, P.J. (1986) Raven Corvus corax populations in two upland regions of north Wales. Bird Study 33: 179-189.

Davis, P.E. & Newton, I. (1981) Population and breeding of Red Kites in Wales over a 30-year period. J.Anim.Ecol. 50: 759-772.

Dawson, D.G. (1985) A review of methods for estimating bird numbers. In Bird Census and Atlas Studies (eds Taylor, K., Fuller, R.J. & Lack, P.C.), pp 27-33. BTO, Tring.

Dennis, R.H. (1984) Highland Raptor Study Group Summary 1983. R.S.P.B., Munlochy.

Dennis, R.H., Ellis, P.M., Broad, R.A. & Langslow, D.R. (1984) The status of the Golden Eagle in Britain. Brit. Birds 77: 592-607.

Dick, D. & MacLeod, I.C. (1986) Raptor results '85. Scottish Birds News 1: 6-7.

Dix, T.J. (1988) Report of the Uist Raptor Study Group for 1988. U.R.S.G., S. Uist.

Dow, D.D. (1978) A test of significance for Mayfield's method of calculating nest success. Wilson Bull. 90: 291-295.

Ewins, P.J., Dymond, J.N. & Marquiss, M. (1986) The distribution, breeding and diet of Ravens Corvus corax in Shetland. Bird Study 33: 110-116.

Fiuczynski, D. & Nethersole-Thompson, D.N. (1980) Hobby studies in England and Germany. Brit. Birds 73: 275-295.

Freeman, S.N. & Morgan, B.J.T. (in press) A modelling strategy for recovery data from birds ringed as nestlings. in Proceedings of 1989 EURING Conference. The Ring.

Fryer, G. (1986) Notes on the breeding biology of the Buzzard. Brit. Birds 79: 18-28.

Fuller, M.R. & Mosher, J.A. (1981) Methods of detecting and counting raptors: a review. Studies in Avian Biology 6: 235-246.

Fuller, M.R. & Mosher, J.A. (1987) Raptor survey techniques. Pages 37-65 in B.A. Giron Pendleton, B.A. Millsap, K.W. Cline & D.M. Bird, eds. Raptor management techniques manual. Natl. Wildl. Fed., Washington, D.C.

Fuller, R.J. (1982) Bird Habitats in Britain. T. & A.D. Poyser, Calton.

Fuller, R.J., Baker, J.K., Morgan, R.A., Scroggs, R. & Wright, M. (1985) Breeding populations of the Hobby Falco subbuteo on farmland in the southern Midlands of England. Ibis 127: 510-516.

Gibbons, D.W. (1989) New Atlas: opening new conservation opportunities. BTO News 161: 1-2.

Glue, D.E. (1977) Breeding biology of Long-eared Owls. Brit. Birds 70: 318-331.

Glue, D.E. & Scott, D. (1980) Breeding biology of the Little Owl. Brit. Birds 73: 167-180.

Goodwin, D. (1986) Crows of the World. 2nd ed. British Museum (Natural History), London.

Green, R.E., Baillie, S.R, Francis, D.M., Ireland, P.L., Mead, C.J., & Pienkowski, M.W. (1978) A review of the Objectives of the BTO Ringing Scheme. BTO, Tring.

Haapala, J. & Saurola, P. (1989) Breeding and population trends of common raptors and owls in Finland in 1988. Lintumies 24: 27-36.

Haworth, P.F. & Fielding, A. (1988) Conservation and management implications of habitat selection in the Merlin Falco columbarius L. in the South Pennines, U.K. Biol. Conserv. 46: 247-260.

Hensler, G.L. (1985) Estimation and comparison of functions of daily nest survival probabilities using the Mayfield method. In (Eds Morgan, E.J.T. & North, P.M.) Statistics in Ornithology, pp 289-301. Springer-Verlag, Berlin.

Hensler, G.L. & Nichols, J.D. (1981) The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bull. 93: 42-53.

Hirons, G.J.M. (1985) The effects of territorial behaviour on the stability and dispersion of Tawny Owl (Strix aluco) populations. J. Zool. (Lond.) (B) 1: 21-48.

Hirons, G.J.M. (1990) Review of Shawyer, C.R. (1987). Ibis 132: 140-141.

International Bird Census Committee (1970) Recommendations for an international standard for a mapping method in census work. Bull. Ecol. Research Committee 9: 45-92.

Johnson, D.H. (1979) Estimating nest success: the Mayfield method and an alternative. Auk 96: 651-661.

Lack, P. (1986) The Atlas of Wintering Birds in Britain and Ireland. T. & A.D. Poyser, Calton.

Lakhani, K.H. & Newton, I. (1983) Estimating age-specific bird survival rates from ring recoveries - can it be done? J. Anim. Ecol. 52: 83-91.

Lockie, J.D. (1955) The breeding habitats and food of Short-eared Owls after a vole plague. Bird Study 2: 53-69.

MacLeod, I.C. (1988) Raptor results 1987. Scottish Bird News 10: 6-7.

MacLeod, I.C. & Dick, D. (1987) Raptor results 1986. Scottish Bird News 5: 4-5.

Mallorie, H. & Flowerdew, J.R. (1988) Mammal Society Small Mammal Survey Results. Poster Display at the Mammal Society Easter Conference. Ripon, Yorkshire.

Mayfield, H.F. (1961) Nesting success calculated from exposure. Wilson Bull. 73: 255-261.

Mayfield, H.F. (1975) Suggestions for calculating nest success. Wilson Bull. 87: 456-466.

Mead, C.J. & Clark, J.A. (1987) Report on bird-ringing for 1986. Ringing & Migration 8: 135-200.

Mead, C.J. & Clark, J.A. (1988) Report on bird ringing in Britain and Ireland for 1987. Ringing & Migration 9:169-204.

Mearns, R. & Newton, I. (1984) Turnover and dispersal in a Pergrine population. Ibis 126: 347-355.

Mearns, R. Newton, I. (1988) Factors affecting breeding success of Peregrines in south Scotland. J.Anim.Ecol. 57: 903-916.

Meek, E.R. (1988) The breeding ecology and decline of the Merlin Falco columbarius in Orkney. Bird Study 35: 209-218.

Mikkola, H. (1983) Owls of Europe. T. & A.D. Poyser, Calton.

Nature Conservancy Council (1988) Internationally important wetlands and special protection areas for birds. NCC, Peterborough.

Nature Conservancy Council & Royal Society for the Protection of Birds (in prep.) Red Data Book on British Birds. T. & A.D. Poyser, Calton.

Newton, I. (1974) Changes attributed to pesticides in the nesting success of the Sparrowhawk in Britain. J. Appl. Ecol. 11: 95-102.

Newton, I. (1979) Population ecology of raptors. T. & A.D. Poyser, Calton.

Newton, I. (1986) The Sparrowhawk. T. & A.D. Poyser, Calton.

Newton, I. (1988) A key factor analysis of a Sparrowhawk population. Oecologia 76: 588-596.

Newton, I., Bogan, J.A. & Haas, M.B. (1989) Organochlorines and mercury in the eggs of British Peregrines Falco pergrinus. Ibis 131:355-376.

Newton, I., Davis, P.E. & Moss, D. (1981) Distribution and breeding of Red Kites in relation to land-use in Wales. J.appl.Ecol. 18: 173-186.

Newton, I., Marquiss, M. & Rothery, P. (1983) Age structure and survival in a Sparrowhawk population. J. Anim. Ecol. 52: 591-602.

Newton, I. & Haas, M.B. (1984) The return of the Sparrowhawk. Br.Birds 77: 47-70.

Newton, I. & Mearns, R. (1987) Population dynamics of peregrines in south Scotland. In Cade T.J., Enderson, J.H., Thelander, C.G. and White, C.M. (eds). Peregrine Falcon Populations: Their Management and Recovery. The Peregrine Fund, Boise, Idaho.

Newton, I., Meek, E.R. & Little, B. (1978) Breeding ecology of the Merlin in Northumberland. Brit. Birds 71: 376-398.

Newton, I., Meek, E.R. & Little, B. (1986) Populations and breeding of Northumberland Merlins. Brit. Birds 76: 155-170.

Noer, H. (in press) Analysis of raptor species. In Proceedings of 1989 EURING Conference. The Ring.

Noer, H. & Secher, H. (1983) Survival of Danish Kestrels Falco tinnunculus in relation to protection of birds in prey. Ornis Scand. 14: 104-114.

North, P.M. (ed) (1987) Ring Recovery Analytical Methods. Proceedings of the EURING technical conference and meeting of the mathematical ecology group of the Biometric Society (British Region) and British Ecological Society. Acta Ornithologica 23: No. 1.

North, P.M. & Morgan, B.J.T. (1979) Modelling heron survival using weather data. Biometrics 35: 667-681.

O'Connor, R.J. (1982) Habitat occupancy and regulation of clutch size in the European Kestrel Falco tinnunculus. Bird Study 29: 17-26.

Parr, S.J. (1985) The breeding ecology and diet of the Hobby Falco subbuteo in southern England. Ibis 127: 60-73.

Percival, S.M. (1988) BTO Owls Project. Interim Report to Project Advisory Committee. BTO, Tring.

Percival, S.M. (1990) Population trends in Barn Owls and Tawny Owls in Britain in relation to environmental change and the use of rodenticides. BTO Research Report, BTO, Tring.

Petty. S.J. (1987) Breeding of Tawny Owls (Strix aluco) in relation to their food supply in an upland forest. Pages 167-179 in D.J. Hill, ed. Breeding and Management in Birds of Prey. University of Bristol, Bristol.

Petty, S.J. & Anderson, D. (1986) Breeding by Hen Harriers Circus cyaneus on restocked sites in upland forests. Bird Study 33: 177-178.

Picozzi, N. (1978) Dispersion, breeding and prey of the Hen Harrier Circus cyaneus in Glen Dye, Kincardineshire. Ibis 120: 498-509.

Picozzi, N. (1984) Sex ratio, survival and territorial behaviours of Hen Harriers Circus c. cyaneus in Orkney. Ibis 126 356-365.

Picozzi, N. & Weir, D. (1974) Breeding biology of the Buzzard in Speyside. Brit. Birds 67: 199-210.

Pollock, K.H., Nichols, J.D., Brownie, C. & Hines, J.E. (1990) Statistical inference for capture-recapture experiments. Wildl. Monogr., 107.

Ratcliffe, D.A. (1980) The Peregrine. T. & A.D. Poyser, Calton.

Ratcliffe, D.A. (1984) The Peregrine breeding population of the United Kingdom in 1981. Bird Study 31: 1-18.

Reynolds, R.T., Scott, J.M. & Nussbaum, R.A. (1980) A variable circular plot method for estimating bird numbers. Condor 82: 309-313.

Rinne, J., Lukki, H. & Saurola, P. (in press) Survival estimates of nestling recoveries: forbidden fruits of ringing. In Proceedings of 1989 EURING Conference. The Ring.

Roberts, J.L. & Bowman, N. (1986) Diet and ecology of Short-eared Owls Asio flammeus breeding on heather moor. Bird Study 33: 12-17.

Roberts, J.L. & Green, D. (1983) Breeding failure and decline of Merlins on a north Wales moor. Bird Study 30: 193-200.

Sara, M. & Zanca, L. (1989) Aspects of censusing Strigiformes. Riv. ital. Orn., Milano 59: 3-16.

Saurola, P. (1989) Breeding strategy of the Ural Owl Strix uralensis. Pages 235-240 in B.-U. Meyburg & R.D. Chancellor, eds. Raptors in the Modern World. WWGBP, Berlin.

Sharrock, J.T.R. (1976) The atlas of breeding birds in Britain and Ireland. BTO, Tring.

Shawyer, C.R. (1987) The Barn Owl in the British Isles. The Hawk Trust, London.

Southern, H.N. (1970) The natural control of a population of Tawny Owls (Strix aluco). J. Zool. (Lond). 162: 197-285.

Spencer, R. & Rare Breeding Birds Panel. (1988) Rare breeding birds in the United Kingdom in 1985. Brit. Birds 81: 99-125.

Steenhof, K. (1987) Assessing raptor reproductive success and production. Pages 157-170 in B.A. Giron Pendleton, B.A. Millsap, K.W. Cline, & D.M. Bird, eds. Raptor management techniques manual. Natl. Wildl. Fed., Washington, D.C.

Stirling-Aird, P. (1988) Central/South-West Perthshire Peregrines and Ravens in 1988. Central Scotland Raptor Study Group, Dunblane.

Taylor, I.R., Dowell, A., Irving, T. Langford, I.K. & Shaw, G. (1988) The distribution and abundance of the Barn Owl Tyto alba in south-west Scotland. Scottish Birds 15: 40-43.

Taylor, K., Hudson, R. & Horne, G. (1988) Buzzard breeding distribution and abundance in Britain and Northern Ireland in 1983. Bird Study 35: 109-118.

Tubbs, C.R. (1972) Analysis of nest record cards for the Buzzard. Bird Study 19: 97-104.

Tubbs, C.R. (1974) The Buzzard. David & Charles, Newton Abbot.

Verner, J. (1985) Assessment of counting techniques. In Current Ornithology (Ed by R.F. Johnson), pp 247-302. Plenum Press, New York.

Village, A. (1981) The diet and breeding of Long-eared Owls in relation to vole numbers. Bird Study 28: 215-224.

Village, A. (1982) The home range and density of Kestrels in relation to vole abundance. J. Anim. Ecol. 51: 413-428.

Village, A. (1983) The role of nest-site availability and territorial behaviour in limiting the breeding density of Kestrels. J. Anim. Ecol. 52: 635-645.

Village, A. (1984) Problems in estimating Kestrel breeding density. Bird Study 31: 121-125.

Village, A. (1990) The Kestrel. T. & A.D. Poyser, Calton.

Watson, D. (1977) The Hen Harrier. T. & A.D. Poyser, Calton.

Watson, J., Langslow, D.R. & Rae, S.R. (1987) The impact of land-use changes on Golden Eagles in the Scottish Highlands. NCC Report No. 720. NCC, Peterborough.

Weir, D. & Picozzi, N. (1983) Dispersion of Buzzards in Speyside. Brit. Birds. 76: 66-78.

White, G.C. (1983) Numerical estimation of survival rates from band-recovery and biotelemetry data. J. Wildl. Mgmt. 47: 716-728.