

RAPTORS

A FIELD GUIDE FOR SURVEYS AND MONITORING



Jon Hardey Humphrey Crick Chris Wernham
Helen Riley Brian Etheridge Des Thompson

Third edition



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THIRD EDITION

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Helen Riley Brian Etheridge Des Thompson



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This book is dedicated to the memory of:

Derek Ratcliffe (1929 – 2005)

Pioneer of systematic surveys of raptors, Derek was a good friend and mentor to many people who have studied these birds. Through his work on pesticides and protected areas, Derek was a leader of the statutory nature conservation movement in Britain during the 1970s and 1980s. He published classic books on the peregrine, the raven and upland birds.

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"This excellent manual will facilitate the standardisation of research techniques and ensure that the collection of data meets the highest possible standards – not just in Britain and Ireland, but across Europe, where the subject matter is equally relevant."

Ibis, July 2007

"The publishers deserve to be congratulated on creating a thoroughly useful publication...if you'd like to see more raptors and understand their lifestyles, you should buy it."

Birdwatch, July 2007

The cover image freezes the moment as a female hen harrier comes in to land or perhaps to pounce on prey, capturing the striking beauty of this upland raptor with its tawny plumage and distinctive white rump or 'ringtail' (very different to the grey, white and black of the male – shown on the frontispiece). A controversial species, due to its association with moorland and the inclusion of red grouse in its diet, the hen harrier is still considered at high risk of illegal persecution in some areas of Britain and Ireland. Robust monitoring is key to understanding the status of this species and the real reasons behind its changing fortunes. Photo: **Laurie Campbell**

We are delighted to be able to reproduce two paintings by the late **Donald Watson**, taken from his book, *The Hen Harrier*, published in 1977. These comprise a male and female hen harrier in forest breeding habitat (frontispiece) and a pair about to engage in a food pass (the CD cover and label). Donald inspired people through his evocative landscape paintings and bird illustrations, and his writing. The paintings are reproduced with kind permission of T & A D Poyser, A&C Black and the Watson family.

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In addition to illustrations at the beginning of each species account, the following illustrations are embedded in the text: short-eared owl (page 1), white-tailed eagle (9), honey-buzzards (15), kestrel (18), hen harrier (23), sparrowhawk (38), goshawk (65), marsh harrier (243), tawny owl (275) and peregrine chicks (281).

Foreword

It is a pleasure to write a foreword for this third edition so soon after earlier editions were published. The continuing demand for this book is a measure of its value to raptor researchers.

Birds of prey have, from time immemorial, fired the human imagination. Over the ages they have been symbolised, even deified. But in 19th century Britain, they were ruthlessly destroyed in the interests of game management, and in the middle of the 20th century some species suffered further massive declines following the introduction of organochlorine pesticides in agriculture. In recent years, however, with increased legal protection, reduced use of organochlorines, and active conservation management, some raptor species have recovered from low population levels. Nevertheless, given the complex range of factors currently influencing raptors, including changes in land management and climate, continuing persecution and declining prey populations, there is a great need for accurate information on numbers, distributions and population changes of these spectacular birds.

Many raptors are elusive, and for birdwatchers, catching fleeting glimpses of the birds themselves, or finding their pellets, plucked prey remains or moulted feathers, has long added to the excitement of days in the field. For scientists, raptors provide the challenge of understanding variation in numbers – either from region to region or from year to year – and the complexities of relationships between predators, prey and habitat.

This book provides in-depth descriptions of field techniques for breeding season surveys of all the diurnal and nocturnal birds of prey which nest regularly in the British Isles. It is based on the collective knowledge and experience of scores of raptor enthusiasts who have learned their field craft over many years. Since the early 1980s, the Raptor Study Groups, now with a membership of more than 300 volunteer specialists organised into regional groups, have played a vital role in collecting data on raptors in Britain and Ireland. These groups have also provided a forum for the exchange of information and ideas about survey techniques, and have been key to the development of national surveys of a growing number of species. It is pleasing to know that so much of that experience is reflected in this book.

As well as this remarkable wealth of personal field experience, the book draws on published and unpublished data and information, and identifies gaps in knowledge. Written and edited by a team of ecologists and raptor specialists, the book is aimed at people with an interest in surveying and monitoring raptors for scientific and conservation purposes. I believe this manual will interest both seasoned as well as less-experienced raptor fieldworkers, and should be invaluable to raptor enthusiasts throughout Europe and beyond.

The present state of our knowledge of these birds is a credit to the many dedicated fieldworkers who have accumulated the necessary information through years of hard physical effort and painstaking observation. People studying raptors should find this book indispensable, and might wish to reflect on the fact that the equivalent of many lifetimes of field experience have been tapped for its production.

Professor Ian Newton OBE, FRS, FRSE

Monks Wood

May 2013

Preface

'If I were to give my own ideas free play, I would arrive at a present population for the birds of prey in Europe amounting to 1% of the number still to be found in Europe 150 years ago'.

With this quote attributed to Professor Karel Voous in 1965, Maarten Bijleveld began his book on *Birds of Prey in Europe* (1974). Almost fifty years on, populations of some species have increased and the percentage is now higher, perhaps nearer 5%. Indeed, if we fast forward to the publication of Birdlife International's (2004) *Birds in Europe: population estimates, trends and conservation status*, we find global statistics and detailed population estimates for raptors in more than 40 European countries. Clearly, there has been a sustained and intensive effort to survey and monitor birds of prey, and steadily our knowledge of these birds and the factors influencing them has improved (e.g. Brown 1976; Newton, 1979; Thompson *et al.*, 2003; Whitfield *et al.*, 2008a; Fielding *et al.*, 2011).

Raptors: a field guide for surveys and monitoring is borne out of our wish to provide robust estimates of population sizes and early means of detecting changes in raptor populations. We are delighted that it has been so well received. First published in 2006, reprinted twice and with a second edition in 2009, this third edition revises and updates the book further. It incorporates feedback from surveyors, correspondents and book reviewers. The photographic guides to the identification of raptor feathers and the development of raptor chicks in the second edition were particularly well received and have been retained along with the invaluable CD of raptor calls.

The guide is for fieldworkers - naturalists, scientists, birdwatchers, ecological contractors, land managers and landowners – to help people record, interpret and report the results of field observations. We are anxious to continue receiving feedback. In future editions we will seek to include more information on assessments of the condition of nestlings, the behaviour and range use of raptors in the non-breeding season, methods for monitoring the numbers and movements of juvenile and non-breeding birds, and molecular techniques for population sampling.

No field guide, no matter how detailed, can ever be a substitute for knowledge and skills developed in the field over time. We strongly advise anyone beginning a study of a raptor to seek advice and guidance from someone with direct experience of the bird. In Britain and Ireland, members of Raptor Study Groups can offer this knowledge and experience for a range of raptor species, and some may be able to provide opportunities to participate in fieldwork alongside an experienced mentor.

Above all else, we urge you to watch birds of prey and enjoy the experience. These birds collectively provide one of the best barometers of the health of our environment, and for millions of people symbolise the majesty, wildness, power, grace and freedom of nature.

Acknowledgements

More than one hundred people have contributed directly to this field guide. We thank the following for contributions, comments, suggestions and observations: Arjun Amar, Beatrice Arroyo, Graham Austin, Harry Bell, Stuart Benn, Rob Bijlsma, Gill Billsborough, Jez Blackburn, Jon Brain, Roger Broad, Keith Brockie, Terry Burke, John Burlison, Nigel Buxton, Ingvar Byrkjedal, John Calladine, Duncan Cameron, Ian Carter, Paul Castle, Anthony Chapman, John Chapman, Jackie Clark, the late Roger Clarke, Liz Coiffait, Ian Collins, Brian Cosnette, Jim Craib, Tony Cross, Peter Cush, Peter Davies, Martin Davison, Cliff Dawson, Roy Dennis, Dave Dick, R.C. Dickson, Andrew Dixon, Ron Downing, Steve Downing, Eddie Duthie, Mark Eaton, Simon Elliot, Ian Enlander, Richard Evans, Alan Fielding, Klaus Dietrich Fiuczynski, Francesco Germi, Paul Gill, Ricky Gladwell, Phil Glennie, Alex Goldau, Peter Gordon, Justin Grant, Mark Grantham, Jeremy Greenwood, Mike Gregory, Ray Hawley, Paul Haworth, the late Roger Hayward, Alan Heavisides, Björn Helander, Mark Holling, Hugh Insley, Sean Jacques, David Jardine, David Johnson, John Atle Kålås, Robert Kenward, Mick Lacey, Roy Leigh, Jerry Lewis, John Lusby, Adam McClure, Liz McDonald, John Mackay, Mike Madders, Garry Marchant, Mike Marchant, Mick Marquiss, John Massie, Wendy Mattingley, Eric Meek, Anthony Messenger, John Milburne, Jane Milloy, Neil Morrison, Steve Moyes, Graham Neville, Ian Newton, Mike Nicol, David Norriss, Aonghus O Domhnaill, Duncan Orr-Ewing, Lorcán Ó Toole, Sandy Payne, Steve Petty, Dave Pierce, Ian Poxton, Colvyn Quaggin, David Ramsden, David Raw, Graham Rebecca, Steve Redpath, Chris Redfern, Gordon Riddle, Steve Roberts, Paul Robertson, Chris Rollie, Martin Roome, Eimear Rooney, Staffan Roos, Ben Ross, Marc Ruddock, Geoff Sample, Andrew Sandeman, Don Scott, Richard Selman, Chris Sharpe, Geoff Shaw, Geoff Sheppard, Mike Shrubbs, Innes Sim, George D. Smith, Andrew Stevenson, Alan Stewart, Patrick Stirling-Aird, Peter Sunde, Bob Swann, Dawn Thompson, David Tierney, Larry Toale, Mike Toms, John Underhill-Day, Dave Walker, Chris Watson, Graeme Watson, the late Jeff Watson, Jim Wells, Sian Whitehead, Phil Whitfield, Derek Whitton, Andy Wilson and John Young. Many of these people have worked with us in drafting texts for the species accounts.

We are delighted to be able to include a section on feather identification and we thank Marian Cieślak and Bolesław Dul for permission to reproduce material from *Feathers: identification for bird conservation*, from the Natura Publishing House (2006), and Marian Cieślak for supplying excellent photographs of raptor feathers. Brian Cosnette, Eddie Duthie, Ron Downing, Mike Groves, Mark Hamblin, R.B.M. Hendricks, David Jardine, Lorcán Ó Toole and an anonymous photographer kindly provided photographs to illustrate the arrangement of raptor feathers and the development of raptor chicks. We thank Lorna Hardey, Jane Milloy, and Steve Roberts for their vignettes and the Royal Society for the Protection of Birds (RSPB) for donating illustrations by John Busby, Mike Langman and Dan Powell. We are grateful to Rob Bijlsma for permission to use data from his 1997 and 1999 publications (see reference list) to produce growth curves for nestlings of a number of raptor species, and to the authors and publishers credited throughout the book for granting us permission to reproduce figures. We thank Nial Smith for the concept for the cover design and Laurie Campbell for the cover photograph.

Geoff Sample has produced an excellent compilation of raptor calls to accompany the book; we thank Cheryl Tipp and Stuart Reading for help in sourcing calls, and the British Library Sound Archive, the BBC Natural History Library and the sound recordists listed on the CD cover for permission to reproduce recordings.

We thank Professor Ian Newton for writing the foreword, and for his encouragement of raptor fieldworkers; his passion for fieldwork and lucid writing is inspirational. We are grateful

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Finally, we must end on a note of sadness, for we really had hoped that Roger Clarke, Roger Hayward, Mike Madders, Derek Ratcliffe, Simon Thirgood, Jeff Watson and Donald Watson would still be with us to enjoy watching raptors. They were close friends and exceptional naturalists.

Des Thompson, Helen Riley, Chris Wernham, Humphrey Crick, Jon Hardey and Brian Etheridge

May 2013

The authors

Jon Hardey is peregrine coordinator of the North East Scotland Raptor Study Group, and a recognised expert on survey and monitoring of peregrines and moorland raptors. He works as a consultant ecologist with both developers and conservation organisations. Recent work has included environmental assessments of bird and mammal populations, habitat surveys for wind farms and other developments, research on peregrines, hen harriers and common gulls for Scottish Natural Heritage (SNH), and baseline surveys of montane breeding bird assemblages in the eastern Grampians.

Dr Humphrey Crick is Head of Profession for Biodiversity at Natural England. Previously he spent many years at the British Trust for Ornithology (BTO) where he led the raptor research programme, analysing Nest Record Cards and leading national surveys of peregrine in 1991 and 2002, and barn owl in 1995-97. He was a member of the Rare Breeding Birds Panel from 1995-2008 and worked hard to develop coordinated raptor monitoring in the UK, including the Scottish Raptor Monitoring Scheme (SRMS).

Dr Chris Wernham is Head of the BTO, Scotland. With a background in population ecology, she was formerly the Senior Population Biologist for ringing-based research at the BTO, and the lead editor of its Migration Atlas project. In her current position, she has a remit to develop the BTO's monitoring of birds in Scotland, both in terms of the design and support of scientific programmes, and also the continued recruitment of volunteer surveyors. She is the BTO's principal representative on the Scottish Raptor Monitoring Group and has a keen interest in raptors and upland birds.

Dr Helen Riley has been involved in a wide range of national and international bird conservation issues while working with the Nature Conservancy Council (NCC), the Joint Nature Conservation Committee (JNCC), SNH and the Secretariat for the international Agreement on the Conservation of Albatrosses and Petrels. She has experience of field surveys of a range of bird species and has been closely involved with the development of the SRMS and programmes of research on upland raptors in Scotland. She now works as an ecological consultant.

Brian Etheridge has worked for RSPB Scotland for the past 26 years and has been involved in long-term studies of breeding hen harriers and red kites for most of them. It follows that he is passionate about their conservation and in the condemnation of the widespread illegal persecution that they and other raptors often suffer in certain quarters. After 10 years in the part-time post, he has recently retired as the Raptor Monitoring Officer for the SRMS. Brian has been studying breeding raptors in the Highlands since 1975 and views himself as an enthusiastic amateur, never happier than in the field with his two collie dogs and a pair of binoculars.

Professor Des Thompson was founder chair of the SRMS and is a Principal Adviser in SNH, where he manages policy and advisory work on biodiversity and climate change. He has special interests in upland and bird ecology, and with colleagues has published a range of books (including *Birds of Prey in a Changing Environment* (2003), *Scotland's Birds of Prey* (2010) and *The Changing Nature of Scotland* (2011)). He had close involvement in the classification and monitoring of Special Protection Areas and Special Areas of Conservation designated under the EC Birds and Habitats directives, respectively. A Trustee of the Field Studies Council and a keen watcher of raptors and waders, Des is working with a team of naturalists to complete a book entitled *Nature's Conscience: the life and legacy of Derek Ratcliffe*.

Editorial note

The taxonomy of bird species referred to in this book follows that used by the British Ornithologists' Union (BOU) for the latest published version of the British list (Dudley *et al.*, 2006). Raptor species names follow the vernacular British names recommended by the BOU (www.bou.org.uk/british-list/bird-names/). Noting that the BOU has adopted the International Ornithological Congress' (IOC) recommendations for English bird names at the international level, we give IOC names for individual species, where different to the vernacular name, in brackets in the contents list and after the first mention in each species account; The IOC names are taken from Gill & Donsker (2012). Vernacular and IOC bird names are also included in Appendix 4.

All website addresses cited in this book have been checked and are correct at the time of publication. As a matter of principle, however, such addresses are given for information only and are not viewed as a formal source of published information.

Part 1



Introduction

1. INTRODUCTION

‘The results, which became available by the end of 1962, were totally unexpected, showing that the peregrine population was declining at a headlong rate and was already reduced to a low level in the southern half of Britain.’

Derek Ratcliffe (1980). *The Peregrine Falcon*. Poyser, Calton.

1.1 Why Monitor Raptors?

The description of field methods for use in surveys and monitoring of raptor populations is the focus of this book. Surveys involve the collection of data on numbers, distribution and breeding success. By drawing these data together, over years and indeed decades, we can monitor changes over time. If we can draw on information relating to the population ecology of raptors as well as environmental data, we can begin to identify the causes of change. Raptor conservation is the primary purpose of such monitoring, with the aim of identifying species which may be in need of conservation action and to help support the legal obligations of governments.

National and international laws to protect wildlife and habitats require assessments of the conservation status of birds of prey (as well as other animal and plant species). Such monitoring has historically focused on rare or threatened species, but there are increasing moves to expand monitoring to commoner species, for example as indicators of environmental quality and biodiversity (e.g. Anon, 2007; Gregory *et al.*, 2003).

Besides conservation, there are other good reasons to monitor raptors (Movalli *et al.*, 2008). As top predators, raptors are often the first species to be affected by a range of environmental pressures, such as changes in habitat availability or quality, prey populations, pollutants and human disturbance. Raptors can provide a cost-effective and sensitive means of detecting environmental change, as was so successfully demonstrated through pioneering research on the response of birds of prey to organochlorines in the environment (a matter we return to below). Today, the UK Predatory Bird Monitoring Scheme continues to monitor the concentrations of pesticides in some species of birds of prey (Walker *et al.*, 2008). The scheme aims to identify and quantify chemical threats to vertebrate wildlife so that mitigation measures can be employed, and to assess the success of such measures.

Illegally shot or poisoned raptors are largely the product of perceived competition for resources (such as gamebirds and livestock) between some people and birds of prey (e.g. Newton, 1979; Anon., 2002; Marquiss *et al.*, 2003). The Royal Society for the Protection of Birds (RSPB) has a long-established monitoring programme for wildlife persecution incidents and results are published annually (e.g. RSPB, 2012a & b). In Scotland, the Scottish Government, RSPB, and Scottish Land & Estates are leading on the development of a database of persecution incidents for raptors and other wildlife. Monitoring of persecution provides information on the success of measures to resolve conflicts between people and wildlife (e.g. Galbraith *et al.*, 2003; Redpath *et al.*, 2004). In the UK, the broad pattern in lowland areas is of increased tolerance or active support for birds of prey, but in some upland areas raptor numbers are still depressed or some species entirely absent because of continuing illegal persecution (RSPB, 2007b; Natural England, 2008; Whitfield *et al.*, 2008a; Fielding *et al.*, 2011).

1.2 The development of raptor monitoring in Britain and Ireland

The first peregrine survey of Great Britain, organised by Derek Ratcliffe for the British Trust for Ornithology (BTO) in 1961 and 1962, marked the advent of systematic monitoring of birds of prey in Britain. It revealed a huge decline in peregrine numbers and led to the discovery of the toxic effects of organochlorine pesticides (Ratcliffe, 1963, 1970, 1993). The work proved, to both statutory (government) and voluntary conservation bodies, the value of mass participation surveys by a partnership of professional and volunteer ornithologists. It also demonstrated the value of collaboration and cooperation between the hitherto rather independent raptor enthusiasts who were gathering large amounts of invaluable information throughout Britain. The bigger picture that emerged from the consolidation of their efforts was vital in demonstrating to government and the agrochemical industries the harmful environmental effects of organochlorine pesticides. This work led to the phased withdrawal of these compounds, and the recovery of the peregrine – a totemic conservation success story (Crick & Ratcliffe, 1995; Ratcliffe, 2003; Banks *et al.*, 2010).

Early studies of other raptors, such as sparrowhawk, kestrel, barn owl and golden eagle, also showed the detrimental effects of persistent pollutants (Prent, 1965). In 1963, the Institute for Terrestrial Ecology (ITE; now the Centre for Ecology & Hydrology, CEH) began a long-term programme of pollutant monitoring in raptors. This work, which continues today, depends upon the submission of carcasses from birdwatchers around the country (Cooke *et al.*, 1982; Shore *et al.*, 2002). The burgeoning interest in raptors and their population dynamics was spurred by the production of two important reviews. The first was the *New Naturalist* volume on *Birds of Prey*, by Leslie Brown (1976). Building on his lifetime involvement with raptors and raptor workers around the world, Brown described the natural history of British raptors, and revealed many gaps in knowledge. The second key publication was Ian Newton's (1979) *Population Ecology of Raptors*, a ground-breaking review of factors affecting the abundance, distribution, survival and productivity of these birds, which set the scene for many subsequent population studies of birds of prey.

Many long-term studies of raptors were begun by ITE/CEH staff, notably of sparrowhawk (Newton, 1986) kestrel (Village, 1990), peregrine (Mearns & Newton, 1988), hen harrier (Picozzi, 1978) and buzzard (Picozzi & Weir, 1974). The RSPB began important studies of raptors in Scotland, notably of the osprey (Dennis, 1983, 1987), golden eagle (Dennis *et al.*, 1984) and hen harrier (Bibby & Etheridge, 1993), and in Wales, on merlin (Bibby, 1986; Bibby & Nattrass, 1986). Staff in the Nature Conservancy Council (and its successor government agencies) made detailed studies of the peregrine (Ratcliffe, 1980, 1993), golden eagle (Watson, 2010), the white-tailed eagle (Love, 1983) and the red kite (Carter & Grice, 2000). Increasingly, these studies have become collaborative, involving substantial cooperation between professional and volunteer bird watchers, giving rise to important books, research papers and reports.

1.2.1 Raptor Study Groups

Studies of raptors in Britain and Ireland have long depended on the efforts of committed and enthusiastic individuals, giving unstintingly of their time and energy. In the 1980s, raptor fieldworkers began to form regional Raptor Study Groups. The impetus for the formation of the first groups, which took place in Scotland, was the coordination of surveys of golden eagle and peregrine, with the primary aim to avoid increased disturbance through multiple visits to the same raptor sites. Instead, sites were allocated to individuals, thereby keeping disturbance to a minimum, but also increasing the total coverage. As well as coordinating

survey coverage, the Raptor Study Groups provided a forum for the exchange of information and ideas about techniques, and they began to collect and collate valuable long-term datasets. This led to the annual reporting of results, for example in the *Raptor Round-up*, published by the Scottish Ornithologists' Club (SOC). The Raptor Study Groups, which have now expanded into England, Wales, Northern Ireland and the Republic of Ireland, have been key to the development of a programme of national surveys for a range of raptor species, achieving a remarkably high level of coverage.

Many of the long-term studies of raptors have also benefited from the wealth of expertise and experience existing within the Raptor Study Groups. Given the widely dispersed nature of raptors, it would have been impossible to cover the ground without voluntary help, and many of the enthusiasts were ringers who were able to add vital information on survival rates and movements of raptors (c. 1,000 adult raptors and 6,000 raptor chicks are ringed annually in Britain and Ireland; see raptor species accounts in Wernham *et al.*, 2002). Volunteer birdwatchers also contribute valuable information to monitoring schemes, such as the Nest Record Scheme run by the BTO (c. 2,000 raptor records received annually, Crick *et al.*, 2003) and the breeding and wintering bird atlases (Sharrock, 1976; Lack, 1986; Gibbons *et al.*, 1993).

With the exception of the Isle of Man, all of the areas covered by this field guide fall within the European Union. As a result of obligations under the 1979 Birds Directive, the first environmental legislation passed by the European Commission (Directive 79/409/EEC, now codified as Directive 2009/147/EC), the Statutory Nature Conservation Agencies in Britain and Ireland embarked on a programme of work to classify Special Protection Areas (SPAs) for birds (Way *et al.*, 1993; Stroud *et al.*, 2001). Identifying a network of important conservation areas for raptors was a challenging task and, here, information collected by the Raptor Study Groups proved essential (both in identifying statutory sites and supporting the conservation of populations in the wider countryside). As the British stronghold for most of the upland raptors, Scotland has classified a large number of SPAs for these birds. Sensitivities surrounding the selection of sites for controversial species, such as the hen harrier, have meant that Scottish Natural Heritage (SNH) has had to present very detailed scientific cases to support the boundaries of proposed SPAs. Detailed discussions between the Statutory Nature Conservation Agencies and the Raptor Study Groups arose from this work, and in combination with the report of the UK Raptor Working Group, consolidated a cooperative approach to fieldwork and data analyses.

1.2.2 The UK Raptor Working Group

The recovery of some birds of prey populations and perceived conflicts, especially with gamebird and racing pigeon interests, led to the formation of the UK Raptor Working Group in the late 1990s (Anon., 2000). The group was jointly chaired by the (then) Department of the Environment, Transport and the Regions (DETR) and the Joint Nature Conservation Committee (JNCC), and had a wide-ranging membership, including Government Environment Departments, the Statutory Country Conservation Agencies (represented by the JNCC), representative bodies for sporting, landowning and pigeon-racing interests and voluntary conservation bodies with expert knowledge. The Raptor Study Groups were also represented, in recognition of their significant contribution to the monitoring and conservation of birds of prey.

A key element of the UK Raptor Working Group's report (Anon., 2000) was a consideration of the abundance, distribution and population trends of raptors. The Group was impressed by the quantity and quality of available data on raptors, and recognised the essential contribution of volunteer raptor fieldworkers in gathering the data. Nevertheless, taking account of the

controversies associated with raptors and the need for very precise information on their status, the Group's recommendations included several that related to enhancements to the monitoring of the UK's raptor populations.

To mark the publication of the UK Raptor Working Group's report, a conference was held to draw together research on birds of prey in Britain and other parts of Europe. The organisers, SNH, the JNCC and the British Ornithologists' Union, intended that the event would be a milestone. It was, and the ensuing publication (Thompson *et al.*, 2003) demonstrated an impressive range and depth of studies, with many benefiting from the synergies of volunteer-professional collaboration.

1.2.3 *The Scottish Raptor Monitoring Scheme*

Some of the key recommendations in the final report of the UK Raptor Working Group concerned the development of improved monitoring and reporting on raptor populations. SNH supported this in part because it needed detailed and accurate data on the location of raptor sightings and breeding attempts in order to designate, manage and monitor Sites of Special Scientific Interest (SSSIs) and SPAs for birds of prey. SNH drew together the major contributors to raptor monitoring in Scotland to forge an agreement to form the Scottish Raptor Monitoring Scheme (SRMS; Anon., 2002; Wernham *et al.*, 2008). Parties to the original agreement were SNH, JNCC, the Scottish Raptor Study Groups (SRSg), BTO Scotland, the Rare Breeding Birds Panel (RBBP), RSPB Scotland, and the SOC; subsequently the Forestry Commission Scotland became a member of the Scheme.

The formation of this Scottish Raptor Monitoring Group (SRMG) has been a significant step in the development of raptor monitoring, and provides a model for similar developments in other countries. The SRMS covers diurnal birds of prey and owls, as well as the raven because of its ecological similarity to raptors (Ratcliffe, 1997). The Scheme is working to three broad objectives, to:

- a) promote better cooperation between the various bodies responsible for gathering information on Scottish raptors;
- b) provide robust information on Scottish raptor populations, in order to determine trends in numbers, range, survival and productivity, and to understand the causes of population changes; and
- c) maintain high and uniform standards for the collection, collation, auditing and analysis of data, and reporting of information.

A Scottish Raptor Monitoring Coordinator is employed by the SRMG, responsible for liaising with the SRSg and other organisations and individuals involved in raptor survey in Scotland, with the aim of collecting and collating raptor data on an annual basis. During the first ten years of the SRMS, 2003 – 2012, the number of records submitted annually increased from just shy of 3,500 to over 5,700, covering 19 species which breed regularly in Scotland. Summaries of these data have been published in ten annual reports (Etheridge, 2005; Etheridge *et al.*, 2006, 2007, 2008, 2010, 2011a, b, 2012, 2013, *in prep*). Reporting is being further developed to provide quantitative trends in occupancy rates and productivity (Wernham *et al.*, 2008; Roos *et al.*, 2011, *in press*). A list of the variables which contributors are asked to provide, and which are included in the SRMS reporting spreadsheet, is included in Appendix 3. The Scheme has developed conservation frameworks for the golden eagle population in Scotland (Whitfield *et al.*, 2006b, 2008a; and see Watson, 2010) and the hen harrier population in the UK (Fielding *et al.*, 2011). Similar work is underway for the peregrine (Humphreys *et al.*, 2006).

Further aims of the SRMS are to better define existing coverage for all raptor species and enhance coverage for species which may be under-recorded (such as honey-buzzard) as well as widespread species (Wernham *et al.*, 2008). For some species, future aims will be met by developing links with other sources of raptor data, such as the Breeding Bird Survey.

This field guide, now in its third edition, originated from the SRMG, with the aim of setting down the standardised field survey methods which have been adopted for individual species over the last 50 or so years, and so that these methods can be consolidated by existing raptor workers and adopted by new fieldworkers.

1.3 International perspectives on raptor monitoring

An extensive review of international monitoring of raptors is outside the scope of this book but two issues are worthy of note. The European Union has adopted an action plan, under the Biodiversity Convention, to meet commitments to significantly reduce the rate of biodiversity loss (EC, 2006). As sentinels of wider environmental health, monitoring of raptors is a key means of contributing to assessments of the success of this action plan (Movalli *et al.*, 2008). To this end, Kovács *et al.* (2008) provide a summary of current monitoring of raptor status and trends in Europe and consider how improvements could be made in terms of pan-European coordination of national initiatives to monitor the status and trends of raptors. A European Science Foundation research networking programme has been established, running for five years from May 2012: Research and Monitoring for and with Raptors in Europe (EURAPMON, www.eurapmon.net). This aims to strengthen the contribution of raptor research and monitoring to the delivery of biodiversity, environmental and human health benefits, including the maintenance and recovery of raptor populations and their habitats, and reduced chemical threats to ecosystem and human health.

The governments of the United Kingdom and the United Arab Emirates have jointly led the development of an international agreement to help conserve migratory birds of prey and owls in the Africa-Eurasian region. This followed resolutions by the World Working Group on Birds of Prey and Owls, held in Budapest in 2003, and the Convention on Migratory Species in Nairobi in 2005, calling for action to tackle the threats faced by these birds. A study commissioned by the UK Government found that more than 50% of migratory raptors in the African-Eurasian region had an unfavourable conservation status, and many were considered to be undergoing rapid or long-term declines (Goriup & Tucker, 2005; Tucker & Goriup, 2005). After two international meetings (in Scotland and the United Arab Emirates) to explore options for international cooperation and to negotiate an agreement, a 'Memorandum of Understanding (MOU) on the Conservation of Migratory Birds of Prey in Africa and Eurasia' entered into effect on 1 November 2008 (www.cms.int/species/raptors/index.htm). Signatories to the MOU agree to adopt, implement and enforce measures to conserve birds of prey and their habitat. The MOU includes an action plan with the general aim of ensuring that all migratory birds of prey (diurnal raptors and owls) in the African-Eurasian region are maintained in, or returned to, favourable conservation status. This includes requirements to monitor populations of migratory raptors to establish reliable population trends.

These recent international developments mean it is all the more important to promote standardised and systematic methods for surveying and monitoring birds of prey.

1.4 The status of raptors in Britain and Ireland

Many species of raptor in Britain and Ireland are recovering from low population levels in the first half of the 20th century, or earlier, in many cases because of a combination of human

persecution and land use change (Newton, 1979; Thompson *et al.*, 2003). Some species had been lost altogether, and their reintroductions to Britain and Ireland have been conservation 'causes célèbres'. The white-tailed eagle, which became extinct in Britain in 1918, is now successfully re-established in the west of Scotland, following the release of a total of 140 young birds from Norway between 1975 and 1998 (Bainbridge *et al.*, 2003); with a total of 67 territorial pairs recorded in 2012 (Etheridge *et al.*, *in prep*). The red kite is another success story, with self-sustaining populations now established in many parts of Britain following reintroductions into Scotland and England, and the recovery of the once relict Welsh population (Carter *et al.*, 2003; Holling & RBBP, 2012). Ireland (including Northern Ireland and the Republic of Ireland) has the most restricted raptor assemblage of any region in Europe, having lost at least eight breeding species historically. In an effort to redress some of the losses, the Irish Raptor Study Group has been a major force behind the current reintroduction projects for golden eagles, white-tailed eagles and red kites in Ireland (www.goldeneagle.ie).

Populations of these birds, as well as the osprey, which famously returned to breed regularly in Scotland in 1954 (Dennis & McPhie, 2003), have been monitored annually since reintroduction or re-establishment. This work has concentrated on recording numbers, distribution, and productivity, providing an invaluable source of information on population growth.

The most recent estimates of breeding populations of raptors in the different countries of Britain and Ireland are given in Appendix 1 (Table A.1). Reviews by the UK Raptor Working Group (Anon., 2000), and Greenwood *et al.* (2003) have demonstrated the international importance of some of the raptor populations in Britain and Ireland, which together hold 5% or more of the European populations of hen harrier, sparrowhawk, golden eagle, kestrel, merlin, hobby, peregrine and short-eared owl (Appendix 1, Table A.2).

Current monitoring of raptors in Britain and Ireland involves a combination of professional fieldworkers, members of the Raptor Study Groups and other volunteer fieldworkers. Periodic national surveys are carried out for scarcer species such as hen harrier, golden eagle, merlin and peregrine. For these and some of the more abundant species, such as buzzard, sparrowhawk and kestrel, annual monitoring is also carried out by members of the Raptor Study Groups in their local areas, the total coverage for individual species varying with the number of raptor workers who choose to study that species. Other schemes also provide information on raptors. For example, the BTO/JNCC/RSPB Breeding Bird Survey (BBS; Risely *et al.*, 2012) provides annual monitoring of population trends for some of the more abundant raptors (sparrowhawk, kestrel, buzzard and, less precisely, hobby).

1.5 A survey and monitoring guide for raptors

In writing this field guide, we have sought to tap the expertise of voluntary and professional raptor workers, much of which was previously unpublished. Originally, it was intended to cover Scotland only, but in response to interest expressed by raptor workers further afield, the scope was expanded to cover Britain, Ireland and the Isle of Man. The resulting book has drawn on the great depth of experience which is found within the raptor fieldworker community throughout this area (and also some European experts), but in particular the members of the SRSB. More than one hundred experienced fieldworkers have contributed to drafts of the text.

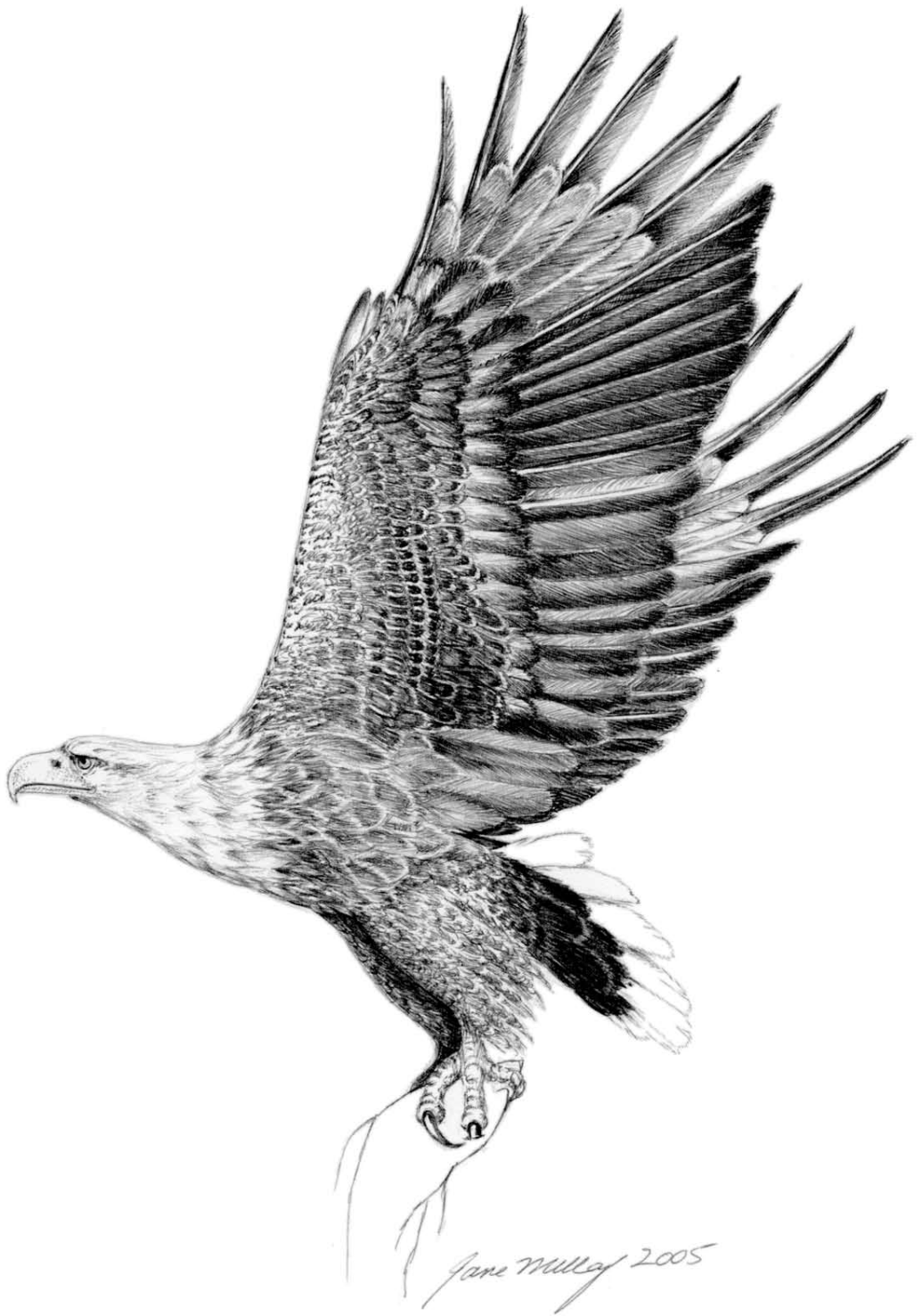
Following a detailed introduction, species-specific sections give accounts of field methods for survey and monitoring. The introductory sections which follow consider briefly the definitions of

survey and monitoring, and the selection of appropriate survey methods. Estimating the size of raptor breeding populations is especially important, and so is described in some detail. Standard definitions and guidance on measurement in the field are provided for count units, breeding success, productivity and breeding failure. A range of further techniques is described, including ringing and other forms of individual marking, remote tracking, and biological and chemical markers. General guidance is provided on the identification of raptors, including the signs which can reveal their presence (e.g. pellets, feathers, plucks and kills), and the types of behaviour (such as territorial displays and courtship feeding) that may aid the interpretation of field observations. Good practices for fieldwork are described, ranging from taking chick measurements for the purposes of estimating age, to advice on recording observations and minimising disturbance. In addition, information is provided on wildlife legislation and requirements for licences to visit nests and ring birds, accessing land for the purposes of survey work, and health and safety. Throughout, details of further reference material are provided.

The species accounts give detailed guidance on field survey methods for 22 species of raptor (including the raven) that breed regularly in Britain and Ireland; shorter accounts are provided for five species that occur less regularly. The species covered include diurnal birds of prey (of taxonomic orders Falconiformes and Accipitriformes), owls (order Strigiformes), as well as the raven (order Passeriformes, family Corvidae). The accounts are based on the knowledge of experts on each of the species, acquired over many years of fieldwork, as well as the scientific literature. We hope that each account will form a useful starting point for anyone seeking to study that species.

Two final sections provide colour plates illustrating the wing and tail feathers for 23 species of raptor which occur in Britain and Ireland, and the growth of raptor chicks for six species. The feather plates are accompanied by an introduction to feathers and in particular their use in bird identification and raptor surveys. The plates of raptor chicks at different stages of development provide an illustration of the appearance of the nestlings of a range of species at different growth stages.

As a supplement to the species accounts, a **CD of raptor calls** is provided. This includes examples of the calls that are most relevant to fieldworkers carrying out raptor surveys, to aid in the identification of species and/or the interpretation of behaviour.



2. SURVEY, SURVEILLANCE AND MONITORING

2.1 Definitions

An ornithological survey involves making systematic observations of the numbers or distribution of a species or assemblage in an area. The aim may be to count the number of individuals or nests of a single bird species, or to record the presence or absence of one or more species in order to assess their distribution. Surveillance entails making such surveys at intervals of time, using comparable methods so that any changes taking place can be identified. Monitoring is the collection and analysis of repeated observations or measurements to evaluate change with respect to defined targets or the degree of deviation from an expected norm (Helawell, 1991; Elzinga *et al.*, 2001). In the context of raptor monitoring, the 'expected norm' can be a previous estimate of the species' population in the area that is being monitored.

A standard or target for monitoring may be that the population estimate remains within a given range of the previous estimate (e.g. within 25%). If a population declines below this limit then an 'alert' may be triggered and conservation-related actions initiated, for example research to investigate the cause of the decline. Thus, whereas surveys and surveillance are to a large extent open-ended, a monitoring programme requires a standard to be defined in advance (Hill *et al.*, 2005). Monitoring leads to an investigation of the causes of population change, and the identification and implementation of management actions to address adverse trends (see Furness & Greenwood, 1993; Greenwood, 2000).

For wildlife monitoring, there are at least five particularly valuable elements which can be built into any programme:–

1. A large number of study plots is required to ensure that the results are generally applicable to the population that is being monitored. Data from a small number of study plots may be biased if the sample contains some atypical sites (see Section 3.1 on population sampling). Inclusion of many sites also allows for the analysis of population data and environmental variables in different locations.
2. Habitat information, gathered concurrently with the population information in a standardised manner, can be used to investigate relationships between distribution, population changes and environmental variables. Habitat information can also be obtained from maps, aerial photographs and satellite imagery, but that gathered along with observations of birds and/or nests is generally of a finer scale. Some habitat variables, such as vegetation height in the vicinity of the nests of a ground-nesting species, or the particular tree species used by a tree-nesting raptor, are more or less impossible to obtain from remotely mapped habitat data.
3. Annual monitoring is useful in allowing long-term trends to be distinguished from short-term fluctuations, such as those which may result from adverse weather conditions. It also allows the investigation of correlations between populations and environmental variables over time.
4. Inclusion of several species in a monitoring programme allows comparisons of population change between species with differing ecologies. Including commoner species can ensure that sample sizes are large enough to detect significant widespread changes.
5. Monitoring all demographic processes (rates of reproduction, survival/mortality, and movement: immigration/emigration/dispersal) provides more insight than the surveillance of numbers alone (Baillie, 1991). The aim is to identify the parts of the life cycle of a species that are driving population changes. Further research can then be targeted more effectively towards investigating the factors behind the change. For example, if breeding

numbers are falling and breeding success is shown to decline but no changes in survival (or mortality) rates are observed, then it is likely that the population decrease is being driven largely by the declining breeding success, and therefore factors that influence breeding success might be the focus of subsequent further investigations. If, conversely, it is the survival rates of adult birds that are falling, and driving the population decrease, then subsequent research may need to focus on different limiting factors, perhaps operating outside the breeding season (e.g. possibly in a remote wintering area).

An example of the insights that can be gained from demographic studies is provided by research on golden eagles in Scotland (Whitfield *et al.*, 2003, 2004a & b, 2006b, 2008a). Although numbers have remained stable overall since the first national survey in 1982 (Dennis *et al.*, 1984; Green, 1996; Eaton *et al.*, 2007), there have been declines in some areas and increases in others. Population modelling has indicated that persecution is responsible for an estimated 3-5% annual mortality in golden eagles, and in the absence of this mortality the Scottish population would increase (Whitfield *et al.*, 2004b). Persecution (assessed by the incidence of records of the use of illegal poison) was found to be most common on grouse moors in eastern and central Scotland (Whitfield *et al.*, 2003), and was associated with a reduction in the age of first breeding of golden eagles, territory vacancies, and the use of territories by non-breeding immatures. By reducing adult survival and creating vacant territories, persecution is thought to create 'ecological traps', attracting mobile immature eagles to areas of apparently suitable habitat where they in turn fall victim to illegal poisoning (Whitfield *et al.*, 2004a).

Although the routine monitoring of numbers and demographic rates will rarely provide a full understanding of any adverse changes, it is important in identifying the investigations required to determine the causes of such changes. The survey techniques described in this book are designed to provide information on the size of raptor breeding populations and also (depending on the number and timing of visits, the accessibility of nests, and the sensitivity of a different species to disturbance) breeding success. Techniques for measuring survival, mortality, dispersal and immigration/emigration rates of raptors normally involve the monitoring of marked individuals (e.g. Summers *et al.*, 2003) or the analysis of genetic or chemical markers from tissues such as feathers or blood samples. Such techniques are considered further in Section 6.

2.2 Choice of survey methods

Birds of prey are generally found at low densities over extensive areas, and this influences the survey methods that are most appropriate for monitoring. In addition to the information and references given below, comprehensive sources of further information on survey techniques are provided by Fuller & Mosher (1987) and Bird & Bildstein (2007), which deal specifically with raptors; and Bibby *et al.* (2000) and Sutherland *et al.* (2004), which describe census techniques for birds.

2.2.1 Counts of occupied home ranges and active nests

To date, surveys of breeding birds of prey in Britain and Ireland have focused largely on the detection of occupied home ranges and the location of active nests within a defined study area – an extensive survey method that has been described as a form of territory mapping (Bibby *et al.*, 2000; Hill *et al.*, 2005). Observers usually work on foot and attempt to cover the survey area evenly, so that all parts are observed. However, as raptors can range over very large areas, surveyors may focus on parts of a study area where the target species has been recorded breeding in the past. Surveys aim to locate all occupied home ranges and active nests within the study area. Fieldworkers tend to focus on one species because of the

large size of home ranges, requirements for intensive observation, and differences in habitat preference, detectability and behaviour between raptor species. Recommendations for this type of survey form the main part of the accounts for each species in this field guide.

If a species is relatively rare or easy to locate, it may be possible to survey the entire breeding population. During the survey, all potential home ranges should be visited and occupancy established by applying a set of rigorous criteria (e.g. Marquiss *et al.*, 1978; Newton *et al.*, 1986; Watson *et al.*, 1989). This approach has been used for golden eagles in Scotland (Green, 1996; Eaton *et al.*, 2007).

For species that are more abundant, foot-searches to locate occupied home ranges and nests can also be used in population sampling surveys, for example for merlin in Britain (Rebecca & Bainbridge, 1998), and hen harrier in the UK and Isle of Man (Sim *et al.*, 2001, 2007). These surveys allow the size of the entire breeding population to be estimated from coverage of a sample of areas within the breeding range, and statistical confidence limits to be placed on the estimates.

2.2.2 *Alternative survey methods: transects and point counts*

These standardised counts offer an alternative approach to surveys that aim to detect all occupied ranges and nests within a survey area. Although not complete enough to measure or estimate absolute population size, such counts can provide a reliable 'index' of the changes in numbers of a species between years. The main approaches are described briefly below, and are highlighted in the individual species accounts for those species for which they might prove particularly appropriate in enhancing existing monitoring effort. These can be used to assess changes in the relative abundance of birds of prey in winter as well as during the breeding season, and can also give information on the habitats used for foraging.

Road Surveys

Large scale transects can be made from motor vehicles (Millsap & LeFranc, 1988; Viñuela, 1997; Resources Inventory Committee, 2001; Leitaó *et al.*, 2001; Boano & Toffoli, 2002). Road surveys are most appropriate for surveying large and obvious species in open habitats. The observer notes all birds of prey seen in a known distance travelled over a recorded time. The detectability of birds will vary with a number of factors, notably the species (size and behaviour), habitat, season, time of day and weather. Surveys might be designed either to coincide with the period of maximum detectability (if known or established by intensive observational study) or to be carried out over periods when detectability is less than maximal but relatively constant, so that the same methods can be repeated from one year to the next, providing a reliable index of change (but no indication of absolute numbers). Observations should be recorded on a map and each record should include the time of the observation and approximate distance and direction from the vehicle. Weather conditions should always be recorded. Road surveys have the advantage of covering large areas in search of widely dispersed species. Continuous surveys from vehicles are obviously not appropriate on busy roads, although approaches based on stopping and making observations from fixed vantage points along the survey route might still be suitable. Road surveys at night using spotlights have been used to survey grassland owls in California (Condon *et al.*, 2005).

Transect surveys on foot

These generally produce a lower encounter rate with raptors than road surveys, but have the advantage of allowing access to areas remote from roads. Observers should walk along a chosen route of predetermined length. Randomly selected routes are always preferable

but, at the least, they should be representative of appropriate habitat(s) for the species under study. Observers should record the position of each bird of prey seen or heard and its approximate distance and direction from the transect line. The time taken to cover the route should also be recorded. In rugged terrain the survey technique may have to be modified (Dawson, 1981), and watches of a fixed duration (stand-watches) from vantage points may be more effective. In closed habitats, the fieldworker should stop at regular intervals and listen for raptors (Resources Inventory Committee, 2001).

Vantage point surveys (stand-watches)

For these, fieldworkers should position themselves on appropriately selected vantage points and record all raptors observed and heard (Resources Inventory Committee, 2001). Vantage point surveys can be a useful supplement to other survey methods, including the detection of occupied home ranges and nests within a discrete study area. Vantage point surveys are therefore often recommended in the species accounts in this field guide, but only at certain stages of the annual cycle, for example, to detect territorial raptors early in the breeding season (e.g. for short-eared owl), and/or to locate nests (e.g. hen harrier). These surveys may also be used to count numbers of individual raptors entering or leaving a winter roost (e.g. red kite); for monitoring the abundance and flightlines of foraging raptors in an area (e.g. environmental impact assessments for windfarms: Whitfield *et al.*, 2005; Madders & Whitfield, 2006; Band *et al.*, 2007); or for counting the numbers of migratory raptors passing a given location. Vantage point surveys can be combined with transect surveys to provide a combined means of monitoring changes in raptor numbers over time (for further details of the general use of such 'point counts' in this context see Bibby *et al.*, 2000).

Call playbacks

These rely on responses by wild birds to the playback of recorded calls, and have considerable potential for surveying nocturnal birds of prey and woodland raptors (Forsman *et al.*, 1977; Mosher *et al.*, 1990; Redpath, 1994; Mosher & Fuller, 1996; Stewart *et al.*, 1996; Bosakowski & Smith, 1998; Gosse & Montevicchi, 2001; Freeman *et al.*, 2006). The observer should broadcast an amplified call from equally spaced points within the survey area, and then, using a compass, plot the direction of calls made in response. Such surveys should always be repeated more than once at any given location, avoiding adverse weather as this can affect both the audibility of calls and bird behaviour. Some species respond more than others, and within a species response rates can be influenced by age and sex, time of year and lunar cycle (Fuller & Mosher, 1987). If the aim of such surveys is to produce an estimate of absolute population size, then validation work to assess the proportion of birds which respond, and variation in the response rate, should be carried out. Of the raptors which occur in Britain and Ireland, this technique is considered to be particularly appropriate for tawny owl and goshawk, and further information is provided in the accounts for these species.

Aerial surveys

Such surveys cover extensive areas, and have been used effectively for some of the larger raptors such as osprey (Henny *et al.*, 1977), golden eagle (Boeker, 1974; McIntyre & Adams, 1999), bald eagle (Grier *et al.*, 1981) and peregrine (White, 1975), including combined surveys of several species. Productivity can often be measured if the surveys are made when there are well-grown young in the nest. Surveys for large, conspicuous nests can also be conducted in winter, reducing disturbance during the breeding season (Resources Inventory Committee, 2001). The observers fly along set transects or grids, the optimal spacing of which depends on the spatial dispersion of the species (Krebs, 1999) and record observations of the target species. Surveys should be carried out at a minimum of 50 m above nest height,

at a speed of 30–130 km per hour (Elliot *et al.*, 1998; Bowman & Schempf, 1999). Ultralights (Looman *et al.*, 1985) have been shown to be more cost-effective than helicopters or light planes in some circumstances.

2.3 Surveys and monitoring in Britain and Ireland

In the UK, a regular programme of national surveys for scarce bird species has been established under the auspices of the Statutory Country Conservation Agencies and RSPB Annual Breeding Bird Scheme (SCARABBS). The SCARABBS programme currently includes several raptor species (including red kite, white-tailed eagle, osprey, marsh harrier, hen harrier, golden eagle, merlin, peregrine and barn owl), producing periodic estimates of the UK breeding population (e.g. Crick & Ratcliffe, 1995; Rebecca & Bainbridge, 1998; Wotton *et al.*, 2002; Eaton *et al.*, 2007; Sim *et al.*, 2007; Banks *et al.*, 2010; Ewing *et al.*, 2011). The general aim is to repeat national surveys of individual species every 12 years, although, depending on their status, some species are surveyed more frequently and some less (e.g. due to concerns about the impact of illegal persecution in some areas of the UK, national surveys of hen harriers are carried out at 6 year intervals). Surveys are designed to be adapted to the particular habits and habitats of the species concerned. Thus, surveys of species such as merlin and hen harrier concentrate on known areas of population concentration but include elements of randomised survey-square selection to assess population status elsewhere, so that population change can be monitored and population size can be estimated in a repeatable manner.

The Rare Breeding Birds Panel (RBBP) plays a key role in the monitoring of the rarer UK raptors (honey-buzzard, red kite, white-tailed eagle, all harriers, goshawk, golden eagle, osprey, merlin, hobby, peregrine, long-eared owl and short-eared owl; www.rbbp.org.uk). Since 1972, the Panel has collated information on the abundance and breeding performance of rare birds (generally those with populations of less than 2,000 pairs). The data are provided by Local Bird Recorders, Statutory Country Conservation Agencies, voluntary conservation bodies (especially RSPB and BTO) and by groups or individual volunteers, especially the Raptor Study Groups. A Rare Breeding Birds Panel has recently been established in the Republic of Ireland.

The Hawk and Owl Trust is primarily involved in raptor conservation measures in Britain and Ireland, but also undertakes some national survey and monitoring work, for example the national barn owl survey in 1982–85 (Shawyer, 1987), and, in collaboration with the BTO and Chris Rollie (for Scotland), the long-running hen harrier winter roost survey, begun in 1983 (Clarke & Watson, 1990, 1997).

Annual information on the relative abundance of some birds of prey in the UK is provided by the BTO/JNCC/RSPB Breeding Bird Survey (BBS), in which breeding bird populations are monitored in randomly selected 1 km squares across the UK (Risely *et al.*, 2012; see www.bto.org/bbs). Standardised transect counts are carried out each year in each square, providing reliable, unbiased information on population changes for the more common birds of prey, particularly for sparrowhawk, buzzard and kestrel. The BBS also provides information on changes in the abundance of important prey for raptors, such as meadow pipit, which can be used to help interpret changes in the numbers and breeding performance of raptors. In the Republic of Ireland, the Countryside Bird Survey (CBS), run by BirdWatch Ireland (www.birdwatchireland.ie), follows the same methods as BBS and is thus complementary.

Another key monitoring scheme for raptors in the UK is the BTO's Nest Record Scheme, undertaken as part of the partnership between the BTO and the JNCC (on behalf of the UK Statutory Country Conservation Agencies, Crick *et al.*, 2003). A network of 550–600 volunteer

nest recorders and recording groups submit a total of approximately 30,000 records to the Nest Record Scheme each year. Each Nest Record Card (NRC) details the history of a single breeding attempt at an individual nest. Observers record species, county, year, place name, six figure grid reference, altitude, habitat and nest site details, dates of each visit, numbers of eggs or young, standardised codes to describe the development stage of nests, eggs, young, activity of the parents and the outcome of the nest (giving the cause of any failure if known). Annual reports are published in *BTO News* (e.g. Leech & Barimore, 2008). A development of nest recording towards relative abundance monitoring is demonstrated by the BTO's Barn Owl Monitoring Programme, which ran for ten years from 2000 (Leech *et al.*, 2009; www.bto.org/volunteer-surveys/completed-surveys/bomp). This monitored breeding performance and nest site occupancy as an index of relative abundance.

Substantial numbers of NRCs are received each year for many of the raptors breeding in the UK, including buzzard, kestrel, sparrowhawk, merlin, peregrine and the raven. The data made an important contribution to Brown's (1976) review of British raptors, and have been used by authors of species monographs (e.g. Bunn *et al.*, 1982 on barn owl; Clarke, 1996 on Montagu's harrier; Scott, 1997 on long-eared owl). NRC data have also been used in studies of the effects of organochlorine pesticides and rodenticides (e.g. Cramp, 1963; Henderson *et al.*, 1993; Newton, 1973, 1974) as well as in general analyses of raptor breeding biology and population dynamics (e.g. Crick, 1993 on merlin; Fiuczynski & Nethersole-Thompson, 1980 on hobby; Garner & Milne, 1997 on long-eared owl; Glue & Scott, 1980 on little owl; Grant *et al.*, 1994 on barn owl; O'Connor, 1982 on kestrel; Percival, 1990 on barn and tawny owls; Tubbs, 1972 on buzzard) and investigating changes in laying dates of upland birds (including raptors) over time (Moss *et al.*, 2005).

As described in Section 1.2.3, the Scottish Raptor Monitoring Scheme has recently begun to publish annual reports of raptor monitoring in Scotland (Etheridge, 2005; Etheridge *et al.*, 2006, 2007, 2008, 2010, 2011a, b, 2012, 2013, *in prep*).



3. POPULATION ESTIMATES

3.1 Population sampling

Raptor populations may be surveyed by covering the whole population (for species which are rare or relatively easy to locate) or by sampling a representative portion. In the latter case, extrapolations are made from the numbers recorded in sample areas to give an estimate for the size of the whole population. Ideally, a sampling strategy involves the randomised selection of defined areas for fieldwork. This avoids any bias arising from surveying only the 'best' areas (e.g. where birds may be most abundant) or the most accessible habitats or locations (such as those close to where most surveyors live). The sampling may need to be 'stratified' by habitat or region to ensure good coverage of all habitats and geographical areas. This involves randomised selection of study areas within specified habitats or regions. It is not always possible to achieve completely randomised samples in a survey design because of the need to incorporate established survey plots, for which valuable long-term survey data are available. Other issues such as the remoteness of some parts of a species' range may also affect the feasibility of randomised sampling.

All study plots, whether randomly selected or selected by fieldworkers, have strictly defined boundaries within which fieldworkers attempt to survey the complete breeding population. This allows the determination of trends through time without potential bias due to variation in observer effort. It also allows for the description or characterisation of plots, in terms of location, area and habitat(s) present, and of course, provides a basis for repeat visits in the future.

Studies based on non-randomised study plots need to be supplemented, at least periodically, with additional randomised surveys that aim to assess whether the breeding range of the population has changed (either contracted or expanded). This allows reassessment of the representativeness of the long-term study plots.

Birds of prey do not nest randomly but rather select locations that provide both secure nest sites and suitable foraging habitat. Knowledge of the requirements for individual species allows the areas to be surveyed within a given study plot to be delimited to some extent (e.g. woodland areas may be omitted from surveys for species which range over open country). Experienced raptor fieldworkers (such as those from the Raptor Study Groups) often work the same areas over many years, accumulating detailed knowledge of the habitats used by birds of prey within their chosen study plot.

3.2 Breeding birds

The survey methods that are the focus of this field guide involve the location of birds that are potentially breeding (occupied sites), and their nests (or other evidence of breeding) if they breed. The aims are to measure both the size of the breeding population and breeding performance or success. The latter is a key population parameter, as it determines potential overall productivity of fledged young. The accounts within this book suggest the minimum number and the timing of visits that are likely to be required to fulfil these aims effectively for each species. In general, one or more visits are required early in the breeding season to establish occupancy, and a minimum of one or two subsequent visits to establish breeding success or confirm that a site is not occupied or that breeding has not taken place.

The results of raptor surveys are generally reported as counts of numbers of 'occupied' sites or ranges, 'territorial pairs' or 'breeding pairs'. Unfortunately there is no universally accepted definition of any of these terms but the following descriptions cover most of the current usage.

3.2.1 Occupied sites

Occupied sites or home ranges are those where a single bird or a pair of birds of the target species is recorded during the breeding season (usually sightings on more than one occasion) or where there is strong evidence from signs (e.g. moulted feathers, pellets, plucks) that birds are present. As well as those occupied by breeding pairs, occupied sites may include areas occupied by non-breeding pairs or single birds unable to secure a mate; hence numbers of occupied sites do not necessarily equate to the number of birds (or pairs) that breed or are capable of breeding in any given year.

3.2.2 Territorial pairs

A territorial pair (or a single bird) is one that defends a territory against intrusions by other raptors of the same species and/or against potential predators. Defence of a territory during the breeding season can provide evidence of intention to breed.

3.2.3 Breeding pairs

The results of surveys presented as numbers of 'breeding pairs' often refer to an estimate of the numbers of pairs that are capable of breeding in any given year, rather than pairs that are actually confirmed as laying eggs in that year. Criteria for identifying breeding pairs may be variously defined to include pairs that defend a nesting territory in the spring (equivalent to territorial pairs as described above); pairs that display or where a male is seen to provide food to a female; pairs that repair or build a nest or prepare a nest scrape; pairs (or a single bird) observed sitting on a nest; or pairs that lay at least one egg. Depending on the intensity of survey, reported figures for 'breeding pairs' may include sites that are known to be occupied by pairs of birds (some but not all of which are confirmed to lay eggs in that year) and also a correction to include some home ranges where only single birds were seen but whose partners may have been missed during the survey (e.g. Banks *et al.*, 2003 for peregrine; Eaton *et al.*, 2007 for golden eagle). Some birds of prey do not always breed as monogamous pairs, for example harriers that may be polygynous (one male mated to two or more females). For such species, breeding populations may be reported in terms of the number of breeding females.

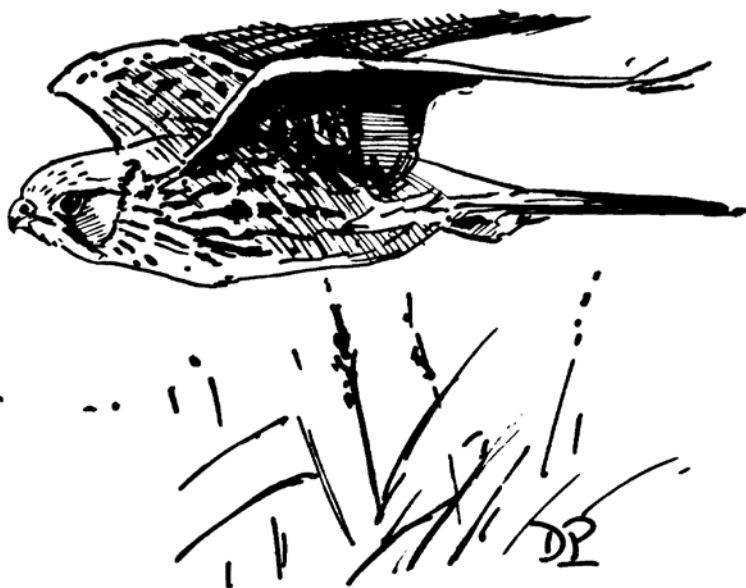
Because of the lack of standard criteria for identifying the count units for breeding birds of prey, it is important that the criteria used to derive population estimates in a particular study are clearly recorded with the stored data and are included with any data reported to monitoring schemes or written up for reports and scientific papers. The species accounts in this field guide describe the observational criteria that can be used to assess the presence of occupied sites and breeding pairs for each raptor species. Fieldworkers are also encouraged to consult books and scientific papers reporting survey results for their target species (many of which are referenced in the species accounts) to see how breeding numbers have been reported elsewhere.

3.3 Non-breeding birds

Non-breeding birds include some that occupy home ranges but fail to lay eggs, and some that do not occupy home ranges at all. Individual birds falling into the first category will be recorded during surveys for occupied sites. Birds are generally recorded as non-breeders if a single bird only is recorded at a given locality in a particular year, or a pair of birds is recorded but no evidence of laying is found. In both situations there is generally some uncertainty attached to defining the number of non-breeding individuals unless very frequent visits are made. The second bird of a non-breeding pair may not be seen during the small number of visits that are generally made, due to a lesser attachment to the nest site, and it can be

difficult to separate pairs that do not lay from those that do lay but fail soon after laying. These problems are exacerbated still further for species that are relatively more cryptic in behaviour or the nests of which are difficult to observe directly (such as the nocturnal owls).

Non-breeding individuals that do not occupy home ranges at all are monitored only rarely because of the difficulty in making systematic observations of this component of the population. This is unfortunate because 'floating' populations of non-breeding birds may be important in buffering breeding populations of many raptor species from short-term fluctuations (Kenward *et al.*, 2000; Whitfield *et al.*, 2004a & b). Such individuals can take up occupation of home ranges if they become available, or if favourable changes in the environment render conditions suitable for more individuals to breed. The cryptic and often wide-ranging behaviour of these non-breeding birds, a high proportion of which are likely to be immatures, makes designing surveys to include them, and differentiate them from birds that occupy home ranges, almost impossible for most species. The non-breeding component of the population reaches a maximum in mid- to late summer, when newly fledged young disperse. Numbers then fall, due to mortality and emigration, through the autumn and winter. The numbers of non-breeders in a raptor population at any given point in time can only be inferred precisely with a detailed knowledge of the demography of the population (age-specific survival rates, reproductive rates, age structure and the proportions of breeding birds of different ages) and movements (immigration, emigration/dispersal and migratory movements). At present, the quality of information available on the demography and movements of most raptor species breeding in Britain and Ireland means that it is generally difficult to estimate numbers of non-breeders with any degree of precision.



4. BREEDING SEASON PARAMETERS

A number of different but related terms are commonly used when discussing the survey and monitoring of birds of prey. In order to ensure that any data collected are both compatible and comparable, it is essential that the definitions of some of the most frequently used terms are agreed. Definitions of some of the most important terms used in the species accounts in this book are given below.

4.1 Home range and territory

During the breeding season, the 'home range' constitutes the immediate area around the nest site and the area over which a raptor or pair of raptors forage (Newton, 1979). A 'territory' or 'nesting territory' is an area which is defended by the resident bird(s) against conspecifics. Some birds of prey, such as golden eagles and tawny owls, defend more-or-less the entire home range; others, such as goshawks and kestrels, defend only part of the home range, around the nest site, and have extensive home ranges for hunting which overlap with those of neighbouring pairs; species such as marsh harriers, which can nest in loose colonies, may sometimes occupy very small nesting territories (further details in species accounts). For species that defend territories during the breeding season, observations of individuals behaving territorially (e.g. displays, aggressive behaviour towards conspecifics or potential predators) can be used to confirm occupancy. Where information is available, the species accounts in this book state whether or not exclusive home ranges or nesting territories are defended during the breeding season.

4.2 Nest sites, nesting ranges and alternatives

The nest and its immediate surrounds (e.g. the ledge on which it is placed) are referred to as the 'nest site'. A pair of raptors may use the same nest site in successive years, as is nearly always the case with established pairs of ospreys (Poole, 1989), or move to a new, alternative nest site. Alternative nest sites may occur in close proximity, for example, a group of sparrowhawk nests in a wood, or they may be several kilometres apart, such as golden eagle nests on different cliffs within a home range. Some species, such as peregrine or goshawk, may have home ranges containing a number of different and widely separated areas with groups of closely spaced alternative nests. The term 'nesting range' is used in this book to refer to the area containing all the alternative nests thought to occur within the home range of a given pair of raptors (Fuller *et al.*, 1985). For some species, nesting ranges may be similar in size to nesting territories; for others the nesting territory may be smaller than the nesting range, if alternative nests are widely spaced and only a small area around an active nest is defended in any one breeding season. Nesting ranges may be recognisable, within and outside the breeding season, by the presence of old and current nests and accumulations of faeces, pellets and prey remains close to favoured eating and roosting perches. Known nesting ranges within a study area can form the initial target areas for survey in a subsequent year. Where evidence of nesting ranges persists outside the breeding season, their locations can be recognised during visits at any time of year and used to identify areas to begin fieldwork in a new study area the following spring. Further information on this is provided in the species accounts.

Evidence for the use by a pair of raptors of alternative nest sites is based on long-term data that show that only one nest site or nesting range in a given locality is occupied in any one year, and/or from the trapping of the same ringed breeding birds on different cliffs (e.g. Ratcliffe, 1993; Watson, 2010). The degree to which such alternatives are used may be, at least in part, due to the availability of suitable nest sites within the home range of any given pair. The alternatives used by adjacent pairs may overlap if the same nest site is used in

different years by different pairs of birds. For example, this occurred in southwest Scotland during the 1980s as the peregrine population increased (Ratcliffe, 1993). Conversely, when a population declines, a pair of birds may begin to utilise former nest sites of an adjacent pair that is no longer present.

The attraction of individual nest sites to successive pairs of many species of raptor is well documented. Peregrine cliffs known to falconers between the 16th and 19th centuries were still in use in the 1930s (Ferguson-Lees, 1951; Ratcliffe, 1993). Some osprey nests in the United States have been in continuous occupation for up to 45 years (Bent, 1938). Cliff ledges and, to a lesser extent, trees might be expected to provide stable places for nests in the long term. For raptor species breeding in less stable habitats, occupation of nesting ranges can also persist over long periods. Merlins breed in tall heather and particular nesting sites may become unsuitable as the heather becomes senescent or is managed by burning. Wright's (1997) study of breeding merlins showed that, over 12 years, there was a clear preference for certain specific nesting localities, indicating that despite habitat change, pairs will continue to breed in the same general area as long as there are suitable stands of heather. Extreme habitat change can, however, cause desertion of nesting ranges. For example, afforestation can lead to the loss of breeding pairs of golden eagle (Marquiss *et al.*, 1985; Whitfield *et al.*, 2001).

4.3 Nests

The nests of the raptor species considered in this book vary from nothing more than a scrape on the ground or a nesting ledge (e.g. ground-nesting merlins and peregrines), through modest nest structures (e.g. hen harrier), to very large or elaborate nests, many of which persist for many years (e.g. golden and white-tailed eagles and the raven). Some raptors utilise the nests of other tree-nesting species, such as crows, for breeding. Of these, some may not add any further material to existing nests (e.g. hobby), while other species, such as buzzard, may add substantial amounts of new material. A further suite of species, including several of the owls and the kestrel, regularly nest in holes, and may also use nest boxes for breeding (see Section 6.6). Guidance on recognising the nests of each species and potential confusion with other species is provided in the species accounts.

4.4 Occupancy

A home range, territory or nesting range is generally recorded as occupied if a single bird or pair of birds is observed during the breeding season, or if there is strong evidence from signs that birds of the target species are present. During a single field visit prior to laying, during laying or during incubation, it is often difficult to establish if a pair of birds or a single bird is present. Two or more visits early in the season to check for occupancy are preferable if at all possible and sightings of bird(s) on more than one occasion provide stronger evidence than a single sighting. Supporting evidence for occupation includes new nests being built or fresh material added to old nests, freshly used nests or scrapes, the presence of droppings, fresh pellets, moulted feathers and prey remains such as plucks. Care must be taken in interpreting evidence of occupation and only recent signs and those that can be attributed to a specific species with certainty should be used. The acceptable criteria for confirming occupation vary between species due to differences in their breeding behaviour and breeding habitat and useful criteria are described in the individual species accounts. It is important to visit nesting ranges early in the breeding season when assessing occupancy because birds that do not lay, or fail after laying, may move away from the nesting area. If a fieldworker builds up knowledge of the pairs breeding in a given study area, then sites with a history of breeding failure can be prioritised for visiting early in the field season in subsequent years.

4.5 Proof of breeding, breeding success and fledging

Breeding is established if it can be ascertained that eggs have been laid and/or, depending on the species, if behaviours that indicate that breeding is ongoing (e.g. a food pass) are observed. It can be difficult to distinguish failure soon after laying from non-breeding unless a nest site has been located and the presence of eggs confirmed (bearing in mind that close approaches to nests during the laying period should be avoided as birds may be very sensitive to disturbance at this time).

Breeding is termed 'successful' if (at least one) young fledge. The definition of fledging varies in the literature but in this book the term is used to refer to the acquisition of the ability to fly by raptor chicks. One or both parents typically continue to feed raptor fledglings for a period of time after they have begun to fly, while the young develop hunting skills. For survey and monitoring purposes, a fledgling raptor, owl or raven should meet the following criteria:

- a young bird that has left the nest but is still dependent on its parents for food (Middleton & Prigoda, 2001);
- capable of flight; and
- fully feathered.

Evidence for successful fledging can be obtained by direct observation of fledged young during nest visits at the appropriate time. If fledging is missed, for example because of uncertainty about the likely date when young will be ready to leave a nest, evidence for successful fledging can be obtained by examining the nests of some raptor species. Supporting evidence for successful fledging includes large accumulations of droppings and the remains of kills in or close to the nest. Down and droppings may also accumulate where fledged young sit regularly after leaving the nest. For example, young sparrowhawks that fledge successfully often leave down in the clefts of branches onto which they move. Similarly, the fledged young of ground-nesting species, such as merlin, will often leave distinctive trails of down that lead away from the nest into the surrounding vegetation (although care is required with interpretation as merlin chicks may also leave the nest before they fledge, see Section 3.3.2 of species account). With experience, recognition of a combination of signs can be used to conclude that successful fledging of young has occurred.

It is often difficult to count young accurately once fledged because they may disperse from the immediate area of the nest and from each other. The minimum number should be recorded if there is any doubt, based on birds seen at the same time or sightings that are considered to involve different fledglings. In such cases, the observer should indicate that more young are possibly present by adding a '+' after the recorded number. The accounts for individual species give guidance on the most suitable times and circumstances for counting fledged young as accurately as possible.

Counts of large feathered young in the nest with little or no down are often given as an estimate of the number of fledged young. Such young are generally capable of leaving the nest and care should be taken on approach in case they fledge prematurely (see Section 7.8 for further guidance). It is preferable to carry out a subsequent visit to the nest to establish whether all the young fledge successfully, but if this is not possible the previous count can be used as an estimate of productivity for many species. Counts of fledged young can be particularly difficult for owls which tend to show extreme asynchrony in hatching so that chicks, especially in large broods, may be at a wide range of ages. In addition, the young of some owl species may leave the nest one to two weeks before they can fly and hide in

surrounding vegetation. Further guidance on methods for counting fledged young is provided in individual species accounts.

The age of the young should be recorded or estimated at each visit when counts are made, as this provides data that can be used to monitor breeding success even when the timing of visits does not allow fledging to be established for certain. A mathematical modelling technique, the 'Mayfield method', can be used to make an estimate of the number of fledged young, based on knowledge of average losses during consecutive stages of chick rearing (Mayfield, 1961, 1975; Dow, 1978; Johnson, 1979; Bart & Robson, 1982; Steenhof, 1987; Crick *et al.*, 2003).

4.6 Productivity

Productivity may be measured or reported in one of three ways: (i) as the average number of young fledged per occupied home range; (ii) the average number of young fledged per breeding pair, territorial pair or female laying eggs; or (iii) the average number of young fledged per successful pair or female. Ideally, data should be collected to allow reporting of all of these measures but often only (ii) and (iii), or (iii) alone are achievable because it is not possible to follow all pairs in a given study area closely enough to record outcomes, and particularly to record pairs that do not lay or fail early in the breeding cycle. Productivity is normally reported on an annual basis for a study population. Whichever method of measuring productivity is reported, the method of calculation and underpinning survey methodology and coverage must be clearly stated.

One aim of measuring productivity is to estimate the average number of young produced per adult female, adult pair or adult bird in a population, which can be used to model the potential future growth of a population and predict whether it is likely to increase or decrease. With respect to this, it is important to note that there are biases inherent in measurement; for example, if a population contains adult birds which do not attempt to breed and do not hold territories, as is the case with many raptor populations (see Section 3.3 above), measures (i), (ii) and (iii) above will all over-estimate productivity relative to the total numbers of adults in the population (e.g. Newton, 1979; Thomson *et al.*, 2001; Green, 2004).

4.7 Breeding failure

Strictly speaking, breeding failure occurs if eggs are laid but no young eventually fledge. In practice, however, for birds of prey it can be difficult to distinguish birds that fail soon after laying from non-breeders that do not lay at all. It is also often difficult to establish the cause of individual cases of nest failure but recording information that may provide clues to this is very useful for interpreting survey and monitoring results. It is important, however, that observers record only what they see, and that assumptions are not made about the causes of failure.

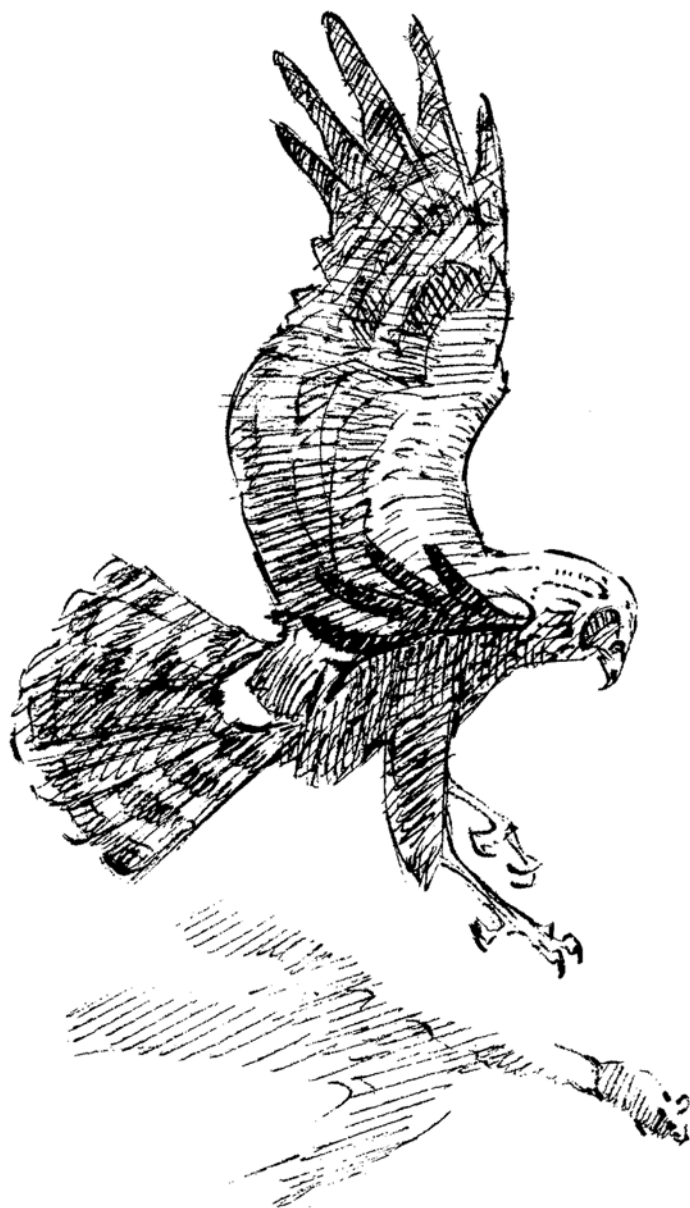
4.7.1 *Natural reasons for non-breeding or failure*

Failure to lay eggs at all, or to complete a clutch, may occur when one or both members of a pair are in poor condition, or immature. Adverse weather, such as heavy snowfall, or a poor food supply, can also prevent laying or clutch completion. Failure during incubation can occur as a result of eggs being deserted or taken by predators. Clutches may be deserted following the death of one of the adults, due to lack of food, harassment by other birds or because of bad weather. Care should be exercised in recording the cause of failure because predation by corvids, gulls or mammalian predators may occur after a clutch has been deserted for other reasons. Nests targeted by predators will often contain eggshells or predator faeces. Some clutches or individual eggs within a clutch may be infertile and may be incubated beyond their full term. This can be caused by chemical pollutants affecting the reproductive behaviour

and fertility of the adults but can also occur naturally. Some young may die before fledging for similar reasons to those leading to clutch desertion. If the young have disappeared from a nest before their predicted fledging date, evidence for hatching can often be found at the nest, including droppings and down/feathers, but establishing any cause of disappearance is often very difficult.

4.7.2 *Persecution*

If human interference is suspected to be the cause of nesting failure, it is important to record accurately any observations that provide supporting evidence (see Section 7.9).



5. IDENTIFICATION AND BREEDING BEHAVIOUR OF RAPTORS

5.1 Identification of raptors

To survey raptors (or any birds) successfully, fieldworkers must be able to identify their subjects accurately to species and also to determine their age and sex (Clark, 2007) where this is possible in the field. As well as visual identification, this will require knowledge of calls, especially for woodland and nocturnal species (see Section 5.4 below). There are a number of specialist field guides for raptor identification. Forsman's (1999) *Handbook of Field Identification* for the *Raptors of Europe and the Middle East* and Clark & Schmitt's (1999) *Field Guide to the Raptors of Europe, the Middle East and North Africa* both provide comprehensive guides to the identification of birds of prey. In addition, *Flight Identification of European Raptors* by Porter *et al.* (1981) is a very useful guide for flying birds and *Collins Birds of Prey* (Gensbol & Thiede, 2008) provides detailed guidance on identification of European species. For owls, König & Wieck (2008) describes all known species worldwide. Many general bird field guides are also useful for the identification of all of the species in this book, for example, the *Collins Bird Guide for Britain and Europe* (Svensson *et al.*, 1999), and *Birds of Europe with North Africa and the Middle East* (Jonsson, 1992); both have clear illustrations showing the variation in plumage, including immature phases, found in European raptors. Species monographs (many of which are referred to in the individual accounts in this book) and *Birds of the Western Palearctic* (Cramp & Simmons, 1980, for diurnal birds of prey; Cramp, 1985, for the owls; Cramp & Perrins, 1994, for raven) are further important sources of reference. BWPI (2006), a DVD version of the *Birds of the Western Palearctic*, includes video footage of many species. Fieldworkers are advised to refer to more than one text, particularly if there is some doubt over identification. Clark (2007) provides useful advice on the field identification of raptors, including ageing and sexing.

If an unfamiliar raptor is seen it may be an 'escaped' captive bird, either an exotic species from another country or, possibly, a hybrid between closely related species. Many of the exotic raptors used in falconry come from North America, and Sibley (2000), or Ferguson-Lees & Christie, (2001, 2005), can assist in the identification of these escapees. Hybrid birds are more difficult. Fieldworkers should note the plumage details and size of any aberrant birds before speculating on their origins. Any suspected falconry escape should also be checked for jesses (trailing straps) on the legs. If any such exotic or hybrid birds are thought to be breeding in Britain, Ireland or the Isle of Man, the appropriate Statutory Nature Conservation Agency should be informed as well as the Local Bird Recorder who will pass information to the Rare Birds Breeding Panel (contact details in Appendix 2).

5.2 Identifying raptor signs

A range of different signs can indicate the likely presence of raptors in an area, although, on their own, signs do not generally allow occupancy to be established definitively. The main signs referred to throughout this guide are the remains of kills, pellets, droppings and feathers. Brown *et al.*'s (2003) guide to the *Tracks and Signs of the Birds of Britain and Europe* is a good overall source of reference for identifying signs left by birds of prey.

5.2.1 Kills

Raptors pluck bird prey and their sharp beaks often leave a hole or broken section of feather quill, whereas small carnivorous mammals, such as weasels, will bite completely through the quill, and larger ones, like red foxes, pull the feathers out in mouthfuls so that the feather plumes are also damaged. Most birds of prey also decapitate their prey and it is possible to see

V-shaped notches cut out of bones, such as the breast-bone, where the beak has bitten. Often all that remains are the head, wings, legs and some body bones. The location, habitat and prey type is often of more use in indicating the likely species of raptor involved than the plucking style. For example, merlins will pluck their prey on prominent stones or fences in moorland, while sparrowhawk plucking stumps will often be found deep inside woodland. Buzzards that eat small mammals and rabbits usually turn the carcasses 'inside-out' and the skin and fur of larger prey may be shredded. Mammalian predators tend to leave carcasses with crushed bones and teeth, as opposed to beak marks (Brown *et al.*, 2003).

5.2.2 Pellets

These are the regurgitated remains of indigestible parts of prey, such as bones, fur and feathers. Most raptors produce these as do other carnivorous bird species, such as grey heron, kingfisher, corvids and gulls. Mammalian carnivore droppings can look similar to raptor pellets, especially those of the red fox, but such droppings are generally found singly, show twisting along the long axis and have a distinct smell. Raptor pellets are often found in groups under a roosting branch, near a plucking post or in buildings. Brown *et al.* (2003) provide a good guide to identifying and analysing pellets and there is a range of guides that describe how to identify the prey remains found in them (e.g. Yalden, 2003; Thomas & Shields, 2008). Like kills, the locations and habitats in which pellets are found often provide a good indication of the species involved but firm identification may not be possible because pellets can vary in form within a species, and overlap in size and type with those of other species. The species accounts provide further guidance on the recognition of pellets and potential confusion with other raptor species.

Pellets that are collected should be placed individually in polythene bags and labelled with the date and location found as well as any other relevant information. As soon as possible afterwards they should be dried slowly, microwaved for a few minutes or frozen to prevent decomposition.

5.2.3 Droppings

Raptors often excrete faeces by lifting the tail and squirting them out as a jet. Droppings are generally most useful for helping to locate the nest sites of raptors on places such as cliffs, through the presence of obvious white splashing. Cliffs may also show patches of bright green, where algae have benefited from the fertilising effect of the regular emission of droppings. Droppings may also be useful for assessing whether a nest hole or building used for nesting or roosting by owls is occupied (e.g. see the species account for barn owl), and even, for red kite, to give an indication of hatching and the rough age of young, based on the spread of 'whitewash' under a nest. Droppings alone will not be species-specific enough to allow occupancy to be established in most cases, or to distinguish between a nesting or roosting site, without additional information or evidence.

5.2.4 Feathers

Moulted feathers found at a raptor roost or nest site, or in the vicinity of signs such as pellets or plucks, should be collected because these can be used both to identify the species and potentially also individual birds, as feather patterning can be unique to a particular individual. The latter has been observed for sparrowhawks (Newton, 1986) and barn owls (Taylor, 1994) for example. Moulted feathers can also be used to detect pollutants (Odjso *et al.*, 2004; Dauwe *et al.*, 2005) and to establish genetic relationships within raptor populations (Rudnick *et al.*, 2005; see also Section 6.4 below). Feathers from plucked prey and pellets can also give clues to the raptor species involved.

Feathers should be collected in paper envelopes (polythene bags should be avoided as they create dampness that will cause the feather to deteriorate rapidly) and clearly labelled with the date and location of finding. Notes should also be made of any clues as to their origin; for example a single feather with a smooth shaft and only trace amounts of skin is likely to be moulted; several feathers together associated with fragments of skin or body may indicate predation (Cieślak & Dul 2006). Wet feathers should be dried as soon as possible after collection. Dirt or stains on feathers can be removed gently with warm water and a little washing up liquid or shampoo. Feathers should then be rinsed in clean water and allowed to drip dry. Paper bags or other 'breathable' containers are recommended for long-term storage, rather than plastic bags (Brown *et al.*, 2003).

Further guidance on feather identification and photographic plates showing the wing and tail feathers of most of the raptor species featured in this book, are included in Section 3 below. These photographs have been very kindly supplied by Marian Cieślak, co-author of the excellent field guide, *Feathers: Identification for Bird Conservation*, from the Natura Publishing House (Cieślak & Dul, 2006).

5.3 Breeding behaviour of raptors

An understanding and recognition of the behaviour of birds of prey is important in assessing the relevance of observations to survey and monitoring. Sightings of adult birds away from a nest site indicate the presence of birds in an area but may not provide clues to their breeding status. Some types of behaviour, however, provide valuable evidence to help assess the breeding status of birds. Some of the main types of behaviour that can be used in this context are described briefly below. Further details of behavioural information of specific value for survey and monitoring purposes is provided in the individual species accounts.

5.3.1 Display

Many species of birds of prey breeding in Britain and Ireland perform some kind of territorial or nuptial display, which can make them easier to detect at certain times of year. The main types of display used are: (i) perching-and-calling; (ii) soaring-and-calling; and (iii) mutual aerial display (Brown, 1976; Hammond & Pearson, 1993). The exact form that such displays take varies between raptor groups and between the habitats used for breeding. Generally, species that breed in woodland are more vocal than those that breed in open habitats. Perching-and-calling is used by many such species, and is the principle display used by nocturnal owls. It is also an important part of nuptial display for many diurnal forest raptors, such as goshawk and buzzard. The most widespread and frequent type of aerial display is soaring-and-calling. Raptors favour bright mornings with light to moderate winds for this type of behaviour, which may include undulating and swooping flights, and spectacular dives. Buzzards and sparrowhawks will do this above the woodland in which they nest. Elaborate versions of some such displays in birds of prey are known as 'sky-dancing' (e.g. hen harrier and osprey). Both birds of a pair may participate in mutual aerial displays, which often involve the most spectacular flight manoeuvres; these may include the two birds of a pair chasing each other in flight-play (e.g. in peregrines) and mock-fighting where talons meet and the birds may spin downwards, locked together, for several hundred feet (e.g. white-tailed eagles).

Many displays are seen prior to the breeding season, particularly in species that are largely sedentary, for example golden eagles display on fine days in winter and early spring. Some displays, such as the descent flights of male harriers, probably only occur late on in the display season, when sexual 'excitement' reaches a peak. Males of many species may continue to display above or near to the nest once eggs are laid and when there are small young but, generally,

display is inhibited somewhat once the male is required to feed a growing brood. Some raptors, such as hen harrier and merlin, may display if breeding failure occurs. Species that occupy their home range year round, such as golden eagles and most peregrines in Britain, may also display 'out-of-season' if eggs are not laid or breeding failure occurs.

The displays of raptors provide clear evidence of the presence of individuals with intention to breed, and for many species give strong evidence for occupation of a home range. Birds may cover large areas of habitat, however, so that display flights may not reveal the location of the nest site. For species which display over very large areas or have the potential to move large distances to breed (e.g. goshawk), display flights may not be a useful indicator of occupancy. Advice on the use of display along with other criteria for establishing occupancy is provided in the individual species accounts.

5.3.2 Egg laying and incubation

Egg laying is generally a sensitive time for raptors, and care should be taken to avoid disturbing birds when they are laying as they may abandon a breeding attempt. As laying approaches, many species line the nest site with some soft fresh material (e.g. leaves, moss, rushes). Eggs are generally laid at intervals of more than one day. The female often begins to incubate before the clutch is complete (e.g. with the first egg in larger species, such as golden eagle and osprey, or after several eggs have been laid in smaller species). In most species, the female does the bulk of the incubation and may be fed by the male at the nest (see 5.3.3 below). In diurnal species in which the male assists with incubation, he generally does this only during daylight hours.

For species that nest in open habitats, such as on cliffs, careful observations of the nest site from a safe distance can often reveal birds either laying or incubating. Laying birds may visit the nest for a brief period only, especially when laying the first eggs. Incubating birds will remain on the nest for extended periods and can often be seen turning the eggs as they settle down. Observations of males bringing food to females (see Section 5.3.3 below) and/or incubation change-overs can also indicate the location of a nest site. However these occur very infrequently in most species, such that extended periods of watching are likely to be required to observe them. Where available, information on change-over times is provided in the species accounts.

5.3.3 Hunting and feeding

Fieldworkers should observe hunting birds of prey carefully, as those that are breeding are likely to return to the nest or its vicinity with prey. Any bird carrying prey should be watched: if the bird flies out of sight, a compass bearing of the direction of flight will often give the appropriate direction in which to search for a nest. Birds delivering prey to the nest may be adults of either sex provisioning young. In addition, males of many raptor species deliver food to females at or near the nest during the courtship/prelaying period, incubation, and while small chicks are being brooded. Food may be presented to the female at the nest or a nearby perch (e.g. sparrowhawk). Some species exhibit spectacular aerial food passes (e.g. most harriers and the peregrine). Watching birds after a food pass can provide a clear indication of the location of a nest. During incubation a male may slip on to the nest to incubate or cover the eggs while the female feeds; and once the chicks have hatched the female may carry prey directly to the nest after a food pass.

The frequency with which food is brought to an incubating female raptor or to young is important in determining the minimum length of time for which it is necessary to watch an area to establish if breeding birds are present. The frequency of food delivery will depend on

the stage of breeding and the type of prey: an incubating female will require less food than a brood of young; the food requirements of young will vary with age; and species that feed on and can carry large prey (e.g. golden eagle, peregrine) will generally visit less frequently than those feeding on very small prey (e.g. hobby, honey-buzzard). In addition, for a given species, small prey will usually be delivered to a nest more frequently than large prey (e.g. hobbies may deliver insects to nestlings at intervals of a few minutes, whereas bird prey may be delivered at intervals of several hours; see Section 2.6 of species account). Details of feeding rates are provided in the individual species accounts where information has been found.

5.3.4 Interpretation of behaviour

It is useful for any fieldworker planning survey or monitoring work on a particular raptor species to find out as much as possible about the breeding behaviour of that species before fieldwork begins. Descriptions and an indication of the importance of the species-specific displays are given briefly in the individual species accounts in this book, but it is recommended that further information is sought from other sources (e.g. Cramp & Simmons, 1980; Cramp, 1985; Cramp & Perrins, 1994; and individual species monographs, referenced in the species accounts). Ideally, fieldworkers should be aware of any behaviours of a species that can be linked unambiguously to establishing occupancy, laying, the presence of young and so on. However, not all behaviour may be interpreted so clearly, which means that careful recording of all behaviour by raptors observed should be carried out for future reference in making decisions about breeding status.

5.4 Vocalisations

A knowledge of raptor calls can be vital for identifying species, establishing the occupation of a nesting range, determining the stage of breeding and in establishing breeding success. The use of calls for detecting occupation by nocturnal owls and woodland raptors (e.g. goshawk) is described in the individual species accounts. For owls or raptors living in more open habitats, where visual observations play a more important part in surveying, calls can still have an important function. Territorial, courtship, or alarm calls can reveal the presence of birds before they are seen.

The use of the repertoire of calls often varies through the breeding cycle. Courtship calls indicate that the birds have not laid or have just started laying. As incubation progresses, both birds of a pair may call as food is brought to the female. These calls can help fieldworkers to locate the nest. After hatching, young often beg for food or call as they are fed. The calls of young can be used to locate nests and confirm breeding success and are particularly useful in the case of owls and woodland raptors. Some raptors can also be sexed due to differences in calls between males and females.

Any fieldworker intending to carry out survey work on a given raptor species is urged to familiarise themselves with appropriate calls, which can be an important aid to field surveys. The **CD of raptor calls** that accompanies this field guide contains examples of key calls of most of the regularly occurring raptor species in Britain and Ireland. These are calls that can be used to identify species or interpret behaviour. Further information on the specific calls of raptors, owls and the raven can be found in species monographs (cited in the individual species accounts), in species accounts of Cramp & Simmons (1980), Cramp (1985), Cramp & Perrins (1994) and BWPI (2006; includes recordings of calls for individual species); as well as compilations of bird calls.

6. ADDITIONAL TECHNIQUES FOR STUDYING RAPTORS

6.1 Ringing

Conventional ringing involves placing an unobtrusive, light-weight, metal ring on a bird's leg. A unique number is engraved on each ring, together with a return address. If a ringed bird is caught subsequently, or found dead, it can then be reported and the recovery details linked with the original details, to show, for example, how far it has travelled and how long it has lived. A range of ring sizes is available for different species (and sometimes for the two sexes within a species where males and females differ considerably in size), to ensure that rings fit correctly and cause the birds no harm or inconvenience. The British and Irish Ringing Scheme is run by the BTO. All ringers require specific training and an appropriate licence to catch birds for the purposes of ringing (see Section 7.1.1 of this book and Chapter 3 in Redfern & Clark, 2001). Further information on training to become a ringer, and details of how to report a ringed bird, can be obtained from the Ringing Unit at the BTO (Contact details in Appendix 2).

In Britain and Ireland, records from ringed birds have proved invaluable, both for providing information on movements and migration (Wernham *et al.*, 2002), and contributing to all aspects of integrated population monitoring (potentially providing information on survival rates, productivity and population size; Baillie *et al.*, 1999; Clark & Wernham, 2002). Ringing has provided the data on which much original knowledge of the seasonal movements of British and Irish birds of prey has been based (e.g. Mead, 1973, 1993; Bunn *et al.*, 1982; Newton, 1986; Heavisides, 1987; Percival, 1990; Watson, 2010; Evans *et al.*, 1999) and has contributed much additional information on their local movements, site fidelity and demography (e.g. Snow, 1968; Newton, 1975; Mearns & Newton, 1984; Kenward *et al.*, 2000).

Many raptor species ringed in Britain and Ireland have relatively higher return rates (in terms of the number of rings reported for a given number of birds ringed) than some other bird groups, so that 'background' ringing over time provides useful broad-scale information, particularly on the movements of each species and how these change through time (Wernham *et al.*, 2002). It can also provide broad-scale information on survival rates. Some specific methodological problems with obtaining survival rates from ringing data exist, however, because most birds of prey are ringed as chicks in the nest (see Crick *et al.*, 1990 for a review of the use of ring recoveries of raptors for estimating their survival rates). In general for raptors, records from conventional ringing can be used most satisfactorily to estimate survival rates if supplementary information from studies of marked adults (such as wing-tagging projects, Section 6.2) is available for analysis in unison.

The return of information per bird handled during conventional ringing is much lower than for some other marking methods (Sections 6.2 and 6.3 below). Other methods, however, with the exception of wing-tagging, are much more expensive, meaning that studies can generally only afford to mark a smaller number of individuals; and these may be less representative of the population as a whole than the larger numbers that can be followed via ringing. Other marking methods may also influence the behaviour of some species, whereas there is generally no evidence of any influence of ringing on behaviour. Equally, there are various biases associated with ringing records (Wernham & Siriwardena, 2002), such as geographical differences in the chances of dead ringed birds being reported, and variation in reporting rates with recovery method (e.g. birds that are killed deliberately might be less likely to be reported; young birds might be more prone to being killed and so on). For these reasons, conventional ringing and the alternative marking methods for raptors (discussed in Sections 6.2 and 6.3

below) should be seen as complementary, and efforts should be made to compare results from different methods whenever possible.

Most ringing of birds of prey involves young in the nest because of the obvious difficulties of catching adult birds. Any such ringing requires consideration for the safety of the fieldworker and the birds. Any ringer planning to ring birds of prey should consult Section 9.3.5 of the *Ringers' Manual* (Redfern & Clark, 2001), which provides information on suitable ages at which young birds of prey should be ringed. Further relevant information on health and safety is provided in Section 7.10 and in the individual species accounts.

6.2 Wing-tagging

Wing or patagial tags are usually made from flexible coloured PVC fabric. They are attached to the bird through the patagium (a flap of skin on the leading edge of the wing), with either nylon or stainless steel pins and washers. Symbols, letters and/or numbers can be painted onto the tags to enable identification of individual birds (see Section 10.3.3 in Redfern & Clark, 2001). Great care must be taken in attaching wing markers and specific training and licensing are required (see Section 7.1.1 below and Chapter 10 of Redfern & Clark, 2001). Advice on making wing tags can be obtained from the BTO Ringing Unit or the Scottish Raptor Monitoring Coordinator (Appendix 2).

Wing tags have been used on a variety of species, particularly on diurnal birds of prey. Birds tagged as chicks in the nest appear to accept the tags as though they are additional feathers. Wing tags are best suited to species that have a slower mode of flight, such as kites, harriers, eagles and buzzards. They are less suitable for species with rapid wing beats or pursuit hunters, such as falcons and sparrowhawks. As wing tags can be observed and any numbers or letters read at a much greater distance than conventional rings, and without re-capture of birds, they have the advantage of generating multiple sightings of the same individual for as long as they are attached. Because they are conspicuous, tags can also substantially increase the likelihood of a dead bird being found and reported. Depending on the method of attachment and skill of the person doing the fitting, wing tags can last at least 10 years on long-lived species, such as red kites.

Tags have been used successfully in Britain on hen harriers (Etheridge *et al.*, 1997; Summers *et al.*, 2003), marsh harriers, red kites (Evans *et al.*, 1997) and white-tailed eagles. Provided sufficient effort is spent searching for marked birds, wing-tagging can be an extremely useful technique for gaining information on the movements, site and mate fidelity, individual breeding performance and survival of diurnal birds of prey. It should not, however, be undertaken without careful consideration for the species involved, the size of the tag used, and the skill and experience of those undertaking the study.

Wing tags may have negative effects on some bird species, including: impairment of flight behaviour; weight loss; a reluctance to migrate; initial discomfort followed by frequent preening or constant annoyance; skin abrasion and feather wear; entanglement and increased mortality; alteration of social behaviour; increased conspicuousness and risk of predation; and reduced breeding success (Varland *et al.*, 2007; Calvo & Furness, 1992). Although minor skin abrasion and feather wear may occur, the available data suggests that correctly fitted wing tags have negligible effects on breeding behaviour and reproductive success of raptors and ravens (Kochert *et al.*, 1983; Smallwood & Natale, 1998; Varland *et al.*, 2007). It is possible that birds tagged as adults may be less tolerant of wing tags than those marked as nestlings, although it may be difficult to distinguish the affects of tags from the stress associated with

the capture of adult birds for marking. The latter has certainly been implicated as a cause for concern for golden eagles studied in Scotland (Gregory *et al.*, 2003). In a North American study, however, no apparent effects of capture and tagging of adult golden eagles on behaviour or breeding success were reported (Phillips *et al.*, 1991). Golden eagles released under the Irish reintroduction project are tagged as pulli, using tags with a rounded bottom edge to reduce wind drag and flapping. Survival of tagged birds (wing- and radio-tagged) has been high and no negative effects of wing-tagging have been identified to date. Birds will continue to be monitored closely so that any effects of wing-tagging on survival or productivity can be assessed (Lorcán Ó Toole, pers. comm.).

In Britain and Ireland, sightings of wing-tagged raptors should be reported to the Ringing Unit at the BTO (contact details in Appendix 2). Where contact details are known or can be obtained, sightings should also be reported as soon as possible to individual project workers or species coordinators, as this can provide an opportunity for researchers to follow-up sightings and obtain additional information.

6.3 Remote tracking

A large range of devices are available for tracking individual birds remotely at distances of a few centimetres or kilometres to a global scale, including radio-transmitters, logging devices and other electronic tags. Remote tracking devices have a clear advantage over ringing and wing-tagging in many applications because they do not rely on cold searching by the observers or on reports from members of the public, and are therefore less subject to spatial biases. However, most such techniques are considerably more expensive than ringing or wing-tagging (by orders of magnitude), meaning that smaller samples of birds are generally followed. Reviews of the range of devices available, and the effects that they may have on birds, are provided by Calvo & Furness (1992), Gauthier-Clerc & Le Maho (2001), Marchant (2002), Wernham & Baillie (2002) and Fiedler (2009). The use of any such devices in Britain and Ireland requires specific licensing permission (see Section 7.1.1 and Chapter 10 of Redfern & Clark, 2001), including stipulations to report on any observed effects on the study species. Some general guidelines for use of these devices, including acceptable weights and methods of attachment, are given in Section 10.4 of Redfern & Clark (2001).

In the context of the survey and monitoring of the raptors that are the focus of this book, there is great potential for remote tracking studies to increase knowledge of the ranging behaviour and daily activity patterns of a number of species, particularly if the costs of the techniques decrease in future so that larger samples of birds can be tagged.

6.3.1 Radio-tracking

Radio tags are light, low-power, very high frequency (VHF) transmitters that are designed to be tracked either manually or from an Automatic Radio Tracking Station (ARTS). They currently have life spans of four months to six years and potential ranges of up to several kilometres, depending on the exact tag specification and battery size, bird behaviour, terrain and tracking location. Ranges may be increased considerably by tracking from raised locations or from the air; for example signals from soaring radio-tagged eagles released under the Irish reintroduction project have been recorded at up to 25 km, when tracking from a mountain top (Lorcán Ó Toole, pers. comm.). In conjunction with suitable tags, ARTS stations can record the presence or absence of tags within a range of up to about 1 km for birds on the ground (Redfern & Clark, 2001). Radio tags are generally custom-built by specialist manufacturers who ensure that they work on appropriate frequencies for Britain and Ireland and that they comply with the relevant EU Directives (see Appendix 1 of Redfern & Clark, 2001 for contact

details of manufacturers). These companies can also supply the receiving equipment and directional antennae needed for conventional hand-held tracking. Anyone planning a radio-tracking study is advised to consult with more than one company over equipment specification and prices, and it may also be worth seeking independent advice from radio engineers.

The limited detection range in conventional radio-tracking means that the technique is most useful for intensive work on local movements. The technique has been widely applied to raptor species to investigate post-fledging behaviour, dispersal of juveniles/immatures and ranging behaviour (e.g. Arroyo *et al.*, 2005, 2006 for hen harriers; Grant & McGrady, 1999 for golden eagle; Tyack *et al.*, 1998; Walls & Kenward, 1995, 1998; Walls *et al.*, 1999; Kenward *et al.*, 2001a for buzzard; Petty & Thirgood, 1989 for tawny owl), mortality and breeding success (e.g. Kenward *et al.*, 1999 for goshawk) and for various more applied studies, such as the predation of pheasants by buzzards (Kenward *et al.*, 2001b).

Further useful technical information, including advice on study design and analytical methods as well as case studies, can be found in Priede & Swift (1992), Kenward (2001, 2004), Millspaugh & Marzluff (2001) and Walls & Kenward (2007).

6.3.2 *Satellite tracking*

Whereas radio tags generally have to be tracked manually and have very limited range, satellite systems allow the remote tracking of birds anywhere in the world. Satellite telemetry has revolutionised the study of raptor migration and aspects of life history such as the movements of immature birds before they settle on breeding territories (Meyburg & Fuller, 2007). The main limitations of satellite tags are their size, weight and cost. Platform terminal transmitters (PTTs) transmit to satellites (e.g. ARGOS), which then transmit the position data back to ground stations. The smallest tags available currently weigh just under 5g. They can be programmed to transmit at regular intervals and to vary the interval several times during the battery life. The larger the tag, the longer the battery life, or the greater the transmission power, and, hence, the accuracy of locations. PTTs provide locations to a maximum accuracy of a few kilometres, or a few tens of kilometres in the case of smaller models (although for transmitters attached to animals the precision of locations may be lower than suggested by manufacturers; Meyburg & Fuller, 2007). Solar-powered PTTs are also available, allowing the tags to transmit indefinitely. Global positioning system (GPS) tags calculate their positions using satellite transmissions (e.g. US NAVISTAR system). They can either store data on board to be accessed upon retrieval, or transmit data back to ground via satellites (which requires a heavier tag). They are larger than PTTs (minimum c. 13g) but can be accurate to within 5–10m.

Recently GSM-GPS transmitters have become available as an alternative to traditional satellite telemetry and have been used to follow the movements of birds of prey (Kendall & Virani, 2012). These units use mobile phone networks to download GPS data collected from animals wearing GSM tags, in the same way that the police can locate a person carrying a mobile phone. The GSM unit can be coupled with sensors and can send coordinates and other data through the GSM system directly to a researcher. In the future, it will be possible to communicate with the tag on the bird and change the settings of the sensors, such as switching them on and off (Fiedler, 2009). At the time of writing, available GSM-GPS transmitters are heavier than PTTs and GPS tags, but, as is the case with other devices, technological advancements are likely to reduce unit size.

A growing number of published studies show the utility of satellite tagging for migration studies on a range of raptor species (e.g. honey-buzzards, Hake *et al.*, 2003; Thorup *et al.*, 2003; golden eagle, McIntyre *et al.*, 2008; lesser spotted eagle, Meyburg *et al.*, 2001; osprey, Kjellen *et*

al., 2001, Alerstam *et al.*, 2006). Recent studies of ospreys, golden eagles, honey-buzzards, and marsh harriers have also been carried out in Britain and Ireland (see www.roydennis.org).

6.3.3 PIT tags

Passive integrated transponder (PIT) tags are very small rods (minimum size c. 12 x 2 mm, weight c. 0.06–0.08 g) that are used to identify individual animals, particularly domestic pets (Gauthier-Clerc & Le Maho, 2001; Redfern & Clark, 2001). Each tag is programmed with a unique number (like a barcode) which can be displayed by a special reading device which energises the tag with radio waves. For use on domestic animals, such tags are usually injected just under the skin but they can be used equally effectively on wild birds by gluing them to feathers (temporary) or rings (more permanent). The tags and readers are relatively cheap and they last a long time because they do not require internal battery power. The main limitation of the technique, currently, is the very low detection distance (ranging from only a few centimetres for the very small tags up to a maximum of c. 1 m). This restricts the use of PIT tags to situations where birds must pass very close to the reader antenna, such as recording incubation durations and feeding rates at nest sites with restricted access routes (e.g. Becker & Wendeln, 1997; Becker *et al.*, 2001 working on terns). Although PIT tags in their current form are unlikely to be of use in studies of the ranging behaviour of raptors, such tags may be valuable for studies of nesting behaviour (in boxes or in situations where a suitable antenna can circle the nest). PIT tags are being used in an ongoing study of the population dynamics of peregrines in Scotland, the aim being to investigate mortality, recruitment and turnover by capturing and re-capturing birds at nest sites. The tags are attached to blank rings which are fitted on one leg of a bird captured as an adult or nestling (the other leg being fitted with a conventional BTO ring). These tags can be read automatically by a battery powered reader placed in a nest, so that birds can be re-captured electronically over successive years. To fit the tags, no special training is required beyond that for ringing; tags are made available free to ringers and tag readers are available on loan (Smith & McGrady, 2008; Smith, 2009).

6.4 Biological and chemical ‘markers’

In the last few decades, techniques for analysing genetic material and also chemical ‘markers’ found in body tissues, such as stable isotopes of some common elements, have advanced markedly. Whilst most techniques are becoming cheaper as available technology and the number of applications increases, they still require either specialist laboratory set-ups or funding to commission analyses from commercial companies, generally necessitating collaboration with those with appropriate expertise. For birds of prey, as with other groups of organisms, these techniques are likely to be used most effectively to answer the types of questions outlined below if the results are interpreted together with those from other broad-scale ecological and demographic work, such as the wide-scale survey and monitoring research that forms the focus of this field guide.

6.4.1 Genetic markers

Modern genetic techniques now play a significant part in conservation research in general, allowing relationships between individuals, populations and species to be delineated. Details of analytical procedures and the growing range of genetic markers that can be used are outside the scope of this manual but several useful reviews are available (e.g. Haig, 1998; Parker *et al.*, 1998; Parkin, 2003). The extraction and amplification of high-quality DNA from previously unusable tissue types, particularly moulted feathers, is now possible (e.g. Leeton *et al.*, 1993; Eguchi & Eguchi, 2000; Rudnick *et al.*, 2005). This means that suitable samples for some applications can now be collected non-invasively without the need for complex training procedures (e.g. for blood sampling) or a specific licence (see Section 7.1.1).

There are a number of areas where genetic analyses might contribute valuable information to survey and monitoring work on birds of prey. Although many species of raptor can be sexed in the field visually, this is often not true of juveniles or young in the nest, although it is often necessary to sex young in order to estimate age with accuracy (see details in each species account). A sex-linked gene that is present in most birds, including raptors, has been identified (Griffiths *et al.*, 1998), which means that most birds can be sexed relatively easily in the laboratory from a tissue sample collected in the field. There is thus much scope for deriving or improving the sex-specific growth curves for young of a range of species. The similarity in genetics between individual birds in a population can be used to calculate dispersal rates: if genetic relatedness is high then dispersal is low and vice versa. DNA fingerprinting involves the determination of genes at a sufficient number of loci to identify individual birds and determine parentage (e.g. Burke & Bruford, 1987; Warkentin *et al.*, 1994; Gavin *et al.*, 1998; Müller *et al.*, 2001). It has been used successfully in criminal investigations to prove that raptors that have been passed-off as captive-bred have not come from the parentage claimed (Wetton & Parkin, 1997). DNA fingerprinting has potential to be a powerful technique for population monitoring as it can be used to determine the identities of individuals using home ranges or nest sites from one year to the next, to measure site fidelity and population turnover. Current research into golden eagle population dynamics in Scotland is using moulted feathers and mouth-swabs of nestlings as sources of DNA. The aims of the project include investigation of the site fidelity of breeding adults and estimation of adult survival rates (Tingay *et al.*, 2008).

Further applications of specific genetic techniques with relevance to populations of birds of prey include assessments of genetic diversity, population viability, inbreeding, effective population size and identifying the founders of new populations. Further details and examples are provided in Haig (1998) and Parker *et al.* (1998). Other applications involve the identification of population- or race-specific genetic markers to investigate migration patterns, habitat requirements, and dispersal/metapopulation structure. For example, population-specific markers have been developed for differentiating neotropical peregrine populations and for establishing the breeding origins of individuals that mix on migration (Longmire *et al.*, 1988, 1991). Broader genetic markers have been investigated recently for their utility in tracking shorebird movements (Haig *et al.*, 1997). Such techniques, if developed for birds of prey, could assist in determining, for example, the breeding origins and composition of wintering populations for species where it is known (e.g. from ring recovery information) that a proportion of the wintering population originates from outside the geographical area of interest (e.g. for sparrowhawks in Britain).

6.4.2 Chemical markers

A growing number of studies have used stable isotope ratios (see Hobson, 1999, 2007, for recent reviews) and other chemical components of body tissues in ecological research. Isotopes are forms of an element that differ in atomic mass due to different numbers of neutrons in the nucleus. Stable ('heavy' and non-radioactive) isotopes of several chemical elements that are abundant in the environment (e.g. carbon, nitrogen, hydrogen, oxygen, sulphur, strontium and lead) have distributions that vary spatially in a predictable manner, such as across broad geographical areas in line with rainfall patterns or major pollution sources, or between different habitats. For example, in general terms the ratio of deuterium (^2H) to normal hydrogen (^1H) in growing-season rainfall varies in a graded manner across continents (Hobson, 1999, 2003; Hobson *et al.*, 2004), and relative ratios become incorporated in plant growth and the tissues of animals further up the food chain. The content of carbon (^{13}C) in animal tissues varies with the proportion of plants with different photosynthetic

pathways (C3 versus C4 or CAM plants) at the base of the food chain, and hence broadly with latitude and major habitat biomes, and marine food sources are markedly higher in the ^{13}C isotope than terrestrial sources. The strontium (^{87}Sr) isotope content varies in terrestrial systems with rock type (see e.g. Chamberlain *et al.*, 1997; Graustein, 1998, for reviews). In any research using stable isotopes, the body tissues to be sampled must be selected carefully, with consideration for the turnover times of the isotopes in question. The isotope 'signature' will reflect the diet on a timescale varying from that over the most recent few days to weeks in metabolically active tissues, such as blood, to that integrated over the entire growth period of an individual in bone or collagen. Tissues made of keratinous material, such as feathers and claws, are inert once formed, so that the composition of their isotope ratios will reflect the geographical location or diet during the time of formation. Because they can be obtained non-invasively, the latter tissue types are favoured in ecological research but their use requires knowledge of the stage in the annual cycle when growth has taken place.

Stable isotope techniques could be of increasing value in a number of areas of research on birds of prey. For example, differences in 'signatures' from marine and terrestrial sources could be exploited to look at the proportion of the diet of species that forage in both these habitats (e.g. white-tailed eagles and the proportion of their diet that comes from marine sources, such as marine fish and seabirds, versus terrestrial sources, including domestic animals; see Bearhop *et al.*, 1999 for an example of research on cormorants). Ratios of appropriate isotopes could also be used, alternatively or in complementary research to that using genetic approaches, to assess the wintering areas of migrant raptors, migratory divides, or the breeding origins and population composition of those wintering in a given geographical area (Hobson, 2005), assuming that there is sufficient knowledge of the growth patterns of the selected tissues (e.g. the moult cycle if feathers are to be used). Studies using stable isotopes to answer these types of questions, and thus knowledge of the approaches that are likely to be successful, are increasing (e.g. Alisauskas & Hobson, 1993; Chamberlain *et al.*, 1997; Rubenstein *et al.*, 2002; Evans *et al.*, 2003; Hobson, 2005; Lott & Smith, 2006). Other chemical signatures might also play a useful part in such studies for some species of bird of prey (e.g. see Parrish *et al.*, 1983 for the use of trace elements to pinpoint peregrine wintering areas).

6.5 Nomograms

This section describes methods for developing nomograms (graphical plots) of egg density and components of chick growth. These nomograms can be used to predict the hatching date of eggs from measurements of egg density, and the age and/or growth stage of nestlings from weight and/or body measurements. Nomograms can allow raptor fieldworkers to use egg or chick measurements, taken during a single nest visit, to estimate hatching or fledging dates and identify the best times for subsequent visits to the nest, for example to ring chicks. This avoids the need for interim visits, which might cause unnecessary disturbance or might be prohibitive in terms of the time available. The calculation of age-specific survival rates of eggs or young (Mayfield, 1961, 1975; Dow, 1978; Johnston, 1979; Bart & Robson, 1982; Steenhof, 1987; Crick, 1993) also relies on the ability to age eggs and/or chicks accurately.

6.5.1 Egg density

During incubation, all eggs lose approximately 16% of their initial mass (Rahn & Ar, 1974; Hoyt, 1979). This loss, which under natural conditions occurs at a roughly constant daily rate, can be attributed almost exclusively to the loss of water vapour from the developing embryo (Rahn & Ar, 1974). A consequence is that the density of an egg decreases as the incubation period progresses (Hoyt, 1979; Furness & Furness, 1981); hence, measurements of egg density can be used to estimate the time left to hatching from a standard curve.

Egg density is calculated by dividing the mass of an egg by its volume, described by the following equation:

$$\text{Egg density} = \frac{W}{K_v LB^2} \quad (i)$$

where L is egg length, B is egg breadth at the widest point, W is egg mass (see Section 7.8.7 for guidance on measuring eggs), and K_v is the volume constant. It is suggested that egg dimensions are measured in millimetres and mass in grams, but other units can be used as long as they are consistent. The volume constant K_v has been measured as 0.51 based on the eggs of 115 species of bird (Hoyt, 1979). It is a function of egg shape but, as there is as much intraspecific as interspecific variability in K_v , this value is considered to be applicable to all but a few species in which the eggs are very pointed.

To create a nomogram, the densities of appropriate samples of eggs of known age need to be measured for each species. In general, measurements should be made on nests in natural situations (not those of captive birds). Such measurements are ideally made daily but could be undertaken at 3–4 day intervals. If eggs are marked then, once the length and breadth of each has been measured, the observer only needs to weigh the eggs on subsequent visits. The fieldwork required to create such a nomogram is intensive. It requires an appropriate licence to handle eggs (Section 7.1.1) and visits need to be planned carefully, and appropriately accessible sites selected, so as to minimise potential disturbance. Such an approach should not be attempted for species that are particularly sensitive to disturbance during laying and incubation.

Once field data have been collected, a graphical plot of egg density against time (e.g. days to hatching) can be produced and used to estimate the hatching date of any egg for which the density is measured. Published examples of such curves are not generally available for raptors in the UK. Examples of nomograms for barn owl and tawny owl, derived by Percival (1990, 1992) from samples of natural nests, are included in the accounts for these species.

Addled or infertile eggs do not lose water as fast as developing eggs (Furness & Furness, 1981) and thus their age cannot be estimated from a calibration curve. Recorders should be able to detect this because such eggs will have a greater density and, as a consequence, will appear to have been laid more recently than the rest of the clutch. During repeat visits, the change in the density will be proportionally less than for eggs showing normal development. If eggs can be numbered in order of laying, then the presence of addled or infertile eggs is easier to detect.

6.5.2 Chick growth

For the purposes of survey and monitoring, it is often important to establish the age of individual chicks. It is generally impractical and undesirable for nest visits to be made on a daily basis around the time of hatching, which would allow precise ageing to be carried out. Instead, it is usually necessary to estimate the age of chicks. As the age of a chick increases, there are associated increases in its weight and various aspects of body size. Where these follow a predictable pattern, it is possible to calculate the age of the chick from a measurement taken in the field on any given date.

Measurements of a given parameter (e.g. weight) against age, from appropriate samples of individuals of known age, can be fitted to a growth curve of known form, typically using either a Logistic, von Bertalanffy or Gompertz equation (Ricklefs, 1968, 1973; Brown & Rothery, 1993; Barkowska *et al.*, 1995 — these all belong to the ‘Richards’ family of growth models,

Richards, 1959). The Logistic equation most frequently provides the best fit for avian data; for example, this has been demonstrated for the barn owl age/weight relationship (O'Connor, 1984; Wilson *et al.*, 1987).

The different measures that have been used as predictors of chick age vary in their usefulness during different stages of chick growth. For many species, structural measurements (e.g. wing length, tarsus, head and bill length) are better predictors of age than body mass because weight change is generally more influenced by short-term fluctuations in food supply. Therefore, chicks of the same age can show quite large variation in mass. Head and bill length can be a useful measurement for determining the age of young raptor chicks but this tends to reach a maximum at about two-thirds of the way through chick development in the nest. Wing length is useful for all but the early stages of chick development (once the feathers have emerged from their sheaths or 'pins').

In order for such information to be used to produce reliable estimates of age, measurements need to be taken on representative samples of chicks of known age and in the wild rather than in captivity. A growth curve can then be produced and used to read off the age of any chick for which a size measurement is taken in the field. As raptors are often sexually dimorphic in size (females being larger), separate curves may be required for male and female chicks, which relies on the identification of suitable criteria for sexing chicks.

Where data are available, growth curves are provided in the species accounts in this field guide, as a starting point for ageing and sexing young. When using these growth curves to estimate the age and/or sex of raptor chicks, fieldworkers should bear in mind that some broods contain a 'runt' which is considerably smaller than its siblings; if they survive, runts and undernourished chicks may fledge to be much smaller than average. Most of the available growth curves are based on small samples and/or data for one particular population of a species and may not apply to that species elsewhere, for example the white-tailed eagle species account (Section 3.5) describes differences in chick growth between different populations of this species in Sweden. For most species it is likely that collection of further data is required to ensure that growth curves are robust enough for general use for raptor fieldwork in Britain and Ireland. Fieldworkers undertaking intensive studies of particular species (and who are in possession of appropriate licences, Section 7.1.1) are encouraged to collect measurements of chicks to add to the limited body of data currently available for ageing and sexing. Guidance on standard methods for taking bird measurements is provided in Section 7.8.

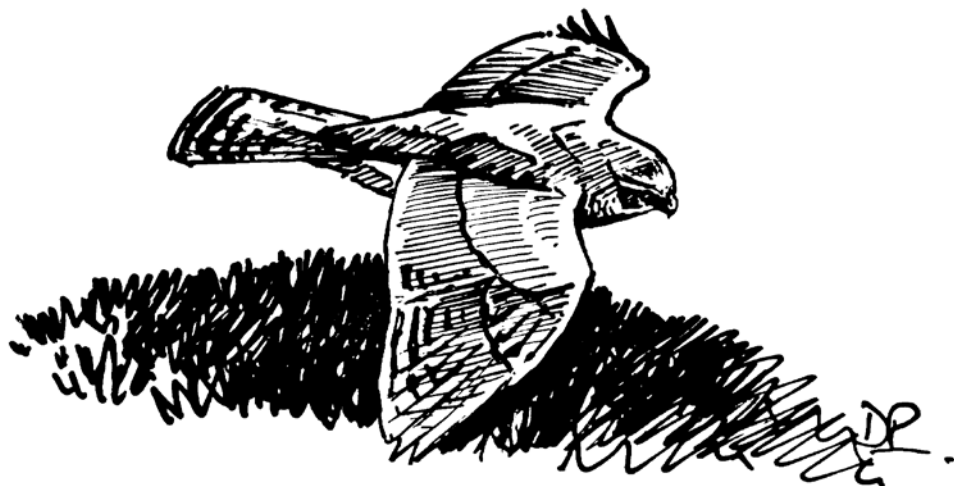
6.6 Nest boxes

Artificial nest platforms or boxes can be a valuable conservation and monitoring tool for many raptor species. Nest boxes are widely used for hole-nesting species, to encourage nesting in an area where natural nest sites are in short supply, and to facilitate access to nests for monitoring purposes. Information on nest box construction is widely available (e.g. du Feu, 2003) and the BTO Nest Record Scheme receives the majority of barn owl, tawny owl, little owl and kestrel records from nest box sites. For these species, long-term studies would be largely impractical without the use of nest boxes. Examples of important nest box studies include Southern's (1970) seminal research on tawny owls in Wytham Wood in Oxfordshire, Village's (1990) population research on kestrels, Taylor's (1994) work on barn owls and Petty's (1992) research on tawny owls in Kielder Forest.

Artificial nest platforms are more rarely used in the UK, although they have been used extensively elsewhere, for example to provide nest sites for ospreys in the United States (Poole,

1989). Nesting baskets have been used to provide a more stable artificial 'corvid-like' nest for species such as long-eared owls (Garner & Milne, 1997) and merlins nesting in trees (Rebecca *et al.*, 1991), and artificial ledges have been created to facilitate peregrine nesting in sites where natural ledges are unsafe or vulnerable to predation.

The use of nest boxes may affect the population under study. Newton (1998) provides several examples of increases in the population density of raptors, such as little owl, barn owl and kestrel, following the provision of nest boxes. This can result in increased competition for resources such as food. Nest boxes can also attract species into an area where there are no naturally suitable nest sites (Dewar & Shawyer, 1996), or may be used in preference to natural sites. For example, Petty (1992) found that 83% of his study population of tawny owls switched to boxes in their first year and that none of the previous natural sites, including ground nests, were used after four years. This switch is likely to have reduced the vulnerability of the nesting birds to predation from species such as red fox, pine marten and goshawk (Petty & Thomas, 2003). In addition, nest boxes are likely to be better insulated against poor weather conditions. Thus, researchers should be aware that nest boxes may improve nesting success through the provision of safer and better insulated nesting sites, but may also have detrimental influences on the study populations, through increased breeding density and competition for resources such as food. Studies based largely on birds using nest boxes may therefore provide results that are not representative of the wider breeding population that does not use boxes.



7. GOOD PRACTICE FOR FIELDWORK

7.1 Legal considerations

7.1.1 *Licences*

Wild birds, their nests and eggs are protected throughout Britain and Ireland. Fieldworkers who intend to handle eggs, or capture and handle and/or ring raptors or their chicks, will need to apply for a ringing permit and/or additional licences. In addition, for some specially protected species, a licence is required to closely approach the nest.

A summary of legislation to protect wild birds and current licensing arrangements – the detail of which varies between different parts of Britain and Ireland – is provided below. **Licensing arrangements may change over time. Fieldworkers are therefore advised to consult the licensing section of the appropriate Statutory Country Conservation Agency, or the BTO Ringing Unit, before starting work** (contacts in Appendix 2).

Permits and licences, or copies of them, should be carried by fieldworkers during survey work. Such permits or licences do not give a fieldworker right of access to land.

Legislation to protect wild birds

In England, Wales and Scotland, the Wildlife and Countryside Act 1981 (as amended by subsequent legislation, see below) makes it illegal to: intentionally kill, injure or take (i.e. capture) any wild bird (with the exception, in the shooting season, of certain game birds and waterfowl); take, damage or destroy the nest of a wild bird while it is in use or being built; or take or destroy eggs. Special penalties for these offences apply for some scarcer species, listed on Schedule 1 of the Act. In addition, for Schedule 1 species, which include many of the raptors dealt with in this book (see species accounts for details) there are additional offences relating to disturbance whilst a bird is building its nest, or in, on, or near a nest with eggs or young; and for disturbance of dependent young.

The Nature Conservation (Scotland) Act 2004 makes some amendments to the Wildlife and Countryside Act as it applies in Scotland. The protection afforded to wild birds, their nests, and eggs and protection against disturbance of Schedule 1 species at the nest and their dependent young, is extended to include ‘reckless’ as well as intentional acts. A person is ‘reckless’ if he or she foresaw there was a risk of disturbance and took that risk, or gave no thought to whether there was a risk or not and failed to consider an obvious risk. Some new offences are added, including that of obstructing or preventing a wild bird from using its nest. There are also two new Schedules (1A and A1) for bird species that are protected from harassment and whose nests are given year-round protection. Golden eagle and white tailed eagle are listed on both schedules and hen harrier and red kite on 1A only.

The Countryside and Rights of Way Act 2000 makes some amendments to species protection provisions in England and Wales, including the creation of a new offence of recklessly disturbing Schedule 1 birds or their dependent young at a nest site. In addition, the Natural Environment and Rural Communities Act 2006 gives year-round protection to the nests of golden eagle, white-tailed eagle and osprey (listed on Schedule ZA1).

In the Isle of Man, the Wildlife Act 1990 provides similar protection for wild birds to that described for the Wildlife and Countryside Act. Schedule 1 (specially protected birds) was updated by the Wildlife Act 1990 (Variation of Schedules) Order 2004 and includes all birds of

prey and owls but not the raven. The concept of 'reckless' disturbance is not included in this Act, although aspects of the legislation are under review and may be updated in the near future.

The Wildlife (Northern Ireland) Order 1985 also performs a similar function to the Wildlife and Countryside Act 1981, making it illegal in Northern Ireland to intentionally kill, injure, or take any wild bird or their eggs or nests. As in Britain, special penalties are available for offences related to birds listed on Schedule 1, for which there are additional offences of disturbing birds at their nests, or their dependent young.

The protection of birds in the Republic of Ireland is covered by the Wildlife Act 1976 which has been amended by the Wildlife (Amendment) Act 2000. Protected wild birds include all birds of prey and owls. It is an offence to hunt wild birds (other than a species for which an open season is specified in an order under section 24 of the Act), to injure them, to wilfully take, remove or destroy eggs and nests or to wilfully disturb birds near to a nest.

Permits and licences for nest visits and ringing chicks

All applications for licences or permits to undertake surveys involving visits to raptor nests will need to be made either to the Statutory Country Conservation Agency covering the area where fieldwork takes place, or to the BTO. Contact details for these Agencies and the BTO Ringing Unit are given in Appendix 2.

The Statutory Country Conservation Agencies in Britain and Ireland grant licences to disturb or take wild bird species for: scientific purposes; for ringing or marking, or examining any ring or mark; for photography; and for the purposes of conservation. In this context, 'take' refers to the temporary capture, possession or control of any live wild bird, or anything derived from such a bird, including, for example, eggs.

In England, Wales and Scotland, the Statutory Country Conservation Agencies have licensed the BTO to issue permits that allow trained ringers to take and ring wild birds using certain methods. Fieldworkers who wish to ring, mark or capture, or to examine rings or marks of non-Schedule 1 raptors in Britain, need only apply to the BTO for a ringing permit. The applicant will need to go through a period of training and assessment appropriate for the type of permit required (contact the Ringing Unit at BTO for further information). If a fieldworker intends to visit the nests of non-Schedule 1 raptors to inspect the contents and measure eggs or chicks, but the chicks will not be ringed, then licence applications should be made to the Statutory Country Agency, or to BTO if records will be submitted to the Nest Record Scheme.

For Schedule 1 birds, licences are required to cover disturbance of birds while they are building a nest or are in, on or near a nest containing eggs or young; or disturbance of the dependent young. Ringing permits do not cover disturbance to Schedule 1 species (although they do cover the actual ringing of these species), so any fieldworker intending to ring, handle, or closely approach the nest sites of Schedule 1 raptors must apply for a separate licence. In England, Scotland and Wales, applications for ringing, marking or handling Schedule 1 raptors, their eggs or their young should be made to the Ringing Unit at the BTO. The BTO issues permits allowing the disturbance of Schedule 1 birds to suitable applicants from England directly, whilst applications from Scotland and Wales are routed to the appropriate Statutory Country Conservation Agency for issue.

All applications for Schedule 1 licences in England, Scotland and Wales that do not involve handling birds, their eggs or their young should be made direct to the Statutory Country Conservation Agency rather than the BTO. The exception is members of the BTO's Nest Record

Scheme, who should apply to the BTO for a Schedule 1 licence even if birds or eggs are not being handled.

Applicants for Schedule 1 licences will be asked: to indicate the species and geographical area they will cover; to describe in some detail the work to be carried out; and (for new applicants) provide the names and addresses of two referees who are familiar with their work and able to advise on their suitability to receive a licence. Such a licence may permit the licence-holder to be accompanied by others, for example in circumstances where additional people are required for health and safety reasons, although their presence may cause additional disturbance. A licence can also include accredited agents who can operate independently of the lead name on the licence. In such cases, licence applicants are asked to provide the names of any assistants who will be working with them.

BTO ringing permits are valid in Northern Ireland, so fieldworkers wishing to ring raptors in Northern Ireland should apply to the BTO as described for England, Scotland and Wales. Separate licences are required to ring or otherwise disturb species on Schedule 1 of the Wildlife (Northern Ireland) Order 1985 and applications for such licences should be made to the Northern Ireland Environment Agency (NIEA).

In the Republic of Ireland, under the Wildlife Act 1976 (as amended), licences are required to take wild birds for ringing or other marking purposes, and a special licence is required to ring at or visit the immediate vicinity of the nests of sensitive species listed on Schedule II of licences issued under Section 32 of the Act (as amended). Applications for both types of licence should be made to National Parks and Wildlife Service (NPWS).

In the Isle of Man, under the terms of the Wildlife Act 1990 and its Variation of Schedules Order 2004, a licence is required to ring birds or disturb Schedule 1 species at the nest. Applications for both types of licence should be made to the Department of Environment, Food and Agriculture. Applicants will be required to demonstrate that they have adequate training or supervision. A BTO permit will also be required for the supply of BTO rings.

Photography

Licences to ring, take or disturb the nest contents of a wild bird do not cover photography. Provided that care is taken to cause no significant additional disturbance, however, this does not preclude the taking of quick, opportunistic photographs to record something interesting that has been found. Fieldworkers whose specific aim is to photograph raptors at nests will require a photographic licence from the appropriate Statutory Country Conservation Agency and should contact the Agency for details of requirements for licence applications.

Licences for wing-tagging and remote tracking

In England, Scotland and Wales, anyone wishing to capture raptors for the purpose of fitting non-conventional rings (e.g. colour-rings), wing tags or remote tagging devices should apply to the Ringing Unit at the BTO, who will check their application and either issue the appropriate licence (in England) or make a recommendation to the appropriate Statutory Country Conservation Agency that a licence is issued (applicants from Scotland and Wales). As is the case for licences to disturb, applicants will need to provide a detailed description of the work to be carried out, including the methodology, rationale and purpose of any scientific study. Applicants will also be asked to provide details of their qualifications and experience. It is normal practise to fit conventional metal rings when other devices are used, requiring a ringing permit from the BTO. In this case, for non-Schedule 1 species (and Schedule 1 birds

in England), the licence to use unconventional marks will be issued as an endorsement to the applicant's ringing permit.

In the Republic of Ireland, licences to capture wild birds for the attachment of wing tags and other marking devices are issued by the NPWS.

Applications for licences to fit wing tags, radio tags and other marking devices in the Isle of Man should be addressed to the Department of Environment, Food and Agriculture.

In Northern Ireland licences to take wild birds for the attachment of wing tags and remote tracking devices are issued by the NIEA.

Licences to take blood or tissue samples

Removal of feathers for DNA identification analysis can be licensed by BTO for England. For Scotland and Wales licence applications should be made directly to SNH and Natural Resources Wales (NRW). Otherwise, anyone wishing to take blood or tissue samples from wild birds in Britain and Northern Ireland will need to apply to the Home Office for a licence. Such licences are issued under the Animals (Scientific Procedures) Act 1986, which covers scientific procedures that are likely to cause pain, suffering, distress or lasting harm. Licensing work is carried out at six regional offices located in Belfast, Cambridge, Dundee, London, Shrewsbury and Swindon. Further details can be obtained from www.gov.uk/research-and-testing-using-animals. Where required, a Home Office licence only covers the actual taking of the tissue sample, so a licence to take or disturb a bird will also be required from the appropriate Statutory Country Conservation Agency and/or the BTO.

In the Isle of Man, enquiries should be made to the Department of Environment, Food and Agriculture in relation to licence for blood and tissue samples.

In the Republic of Ireland, licences to take blood or tissue samples are issued under the Wildlife Act 1976 (as amended) and applications should be made to the NPWS.

7.1.2 Access

Licences granted for ringing or nest visiting do not give the fieldworker the right of access to land. Access rights are covered by legislation in each country.

In Scotland, Part 1 of the Land Reform Act (Scotland) 2003 establishes for everyone a statutory right of access to most land and inland water for recreational purposes, educational purposes (concerned with furthering a person's understanding of the natural and cultural heritage), some commercial purposes (where the activities are the same as those undertaken by the general public), and for crossing over land or water. Access rights must be exercised responsibly. The term 'responsible' refers to the legal requirement for those taking access not to cause unreasonable interference with the rights of any other person, including access rights and rights associated with land ownership. Land managers also have responsibilities under the Land Reform Act to respect access rights and not cause unreasonable obstructions to people crossing their land. If there is concern that access rights have been unreasonably withheld or restricted, then the Local Authority or the Local Access Forum can provide advice and assistance.

The right of access in Scotland extends to individuals undertaking surveys of the natural heritage where these surveys have a recreational or educational purpose within the meaning

of the legislation, and is considered to cover fieldworkers carrying out raptor surveys on a voluntary basis (including those that may be in receipt of travel expenses through an SNH grant). Access rights also extend to those carrying out, commercially or for profit, any activity that the person taking access could undertake otherwise (as a member of the general public). While this indicates that those undertaking raptor surveys in a contractual capacity do not need to seek access permission, fieldworkers are advised to consider the circumstances of each project. Under the Scottish Outdoor Access Code, people organising surveys that are intensive over small areas or require frequent repeat visits are asked to consult any relevant land manager(s) and provide details of the proposed survey methodology. Fieldworkers carrying out commissioned surveys under contract to SNH will be asked to consult with landowners before taking access for raptor surveys. Full details of the new access rights, as well as guidance on the responsibilities with respect to access of those who own and manage land and water, are included in the Scottish Outdoor Access Code (available at www.outdooraccess-scotland.com).

In England and Wales, the permission of individual landowners should normally be sought before entering private land in order to survey raptors. However, extensive areas (over a million hectares) of open countryside (mountain, moor, heath and down) and registered common land have been opened for public access under the Countryside and Rights of Way Act 2000. Access is available on such areas (subject to restrictions) for 'open-air recreation', which would include the observation of raptors by volunteers (see www.countrysideaccess.gov.uk or www.naturalresourceswales.gov.uk and the latest edition Ordnance Survey Explorer map series for more information and maps showing areas that have been defined as open access land). For survey work involving frequent repeat visits to a limited area, fieldworkers should continue to liaise with landowners. Individuals carrying out survey work for commercial reasons, or as part of their paid employment, should also seek the permission of the landowner. In England and Wales, trespass is not a criminal offence but may be the subject of action by the landowner. If somebody is on open access land for reasons other than 'open-air recreation', they may be asked to leave (because they have no statutory right of access). This does not apply to statutory rights of way, where a right of access to pass and re-pass applies at all times.

In the Republic of Ireland there is no general right of access and permission should always be sought from landowners before entering private land. Liability in case of injury may be an issue for landowners. Raptor fieldworkers carrying out surveys in their own time fall under the concept of 'recreational users' under the Occupiers Liability Act 1995 and are responsible for their own safety. Within Irish National Parks, which are State owned and run by the NPWS, there is open access for walkers. The forestry company Coillte (www.coillte.ie), which owns much of the forestry in the Republic of Ireland, also has a policy of open access to its lands but permission should be sought for vehicular access to forest tracks.

In the Isle of Man, fieldworkers wishing to carry out raptor surveys over private land will require access permission from landowners. Public access is permitted over areas of Crown and Common Lands (public ramblage) in the uplands. Surveyors are however advised to make contact with the Forestry Office (Department of Environment, Food and Agriculture) before undertaking fieldwork.

Northern Ireland does not have general freedom to roam legislation. Most rural access is via public rights of way, which are covered by the Access to the Countryside (NI) Order 1983. Under common law, walkers on rights of way may only do things which are reasonably

incidental to their legal right to pass and re-pass. This, therefore, may not include a right to undertake survey work and fieldworkers are advised to seek landowner's permission prior to entering private land. Permission to enter public sector land, owned for example by the Forest or Water Service, may be best sought on a province-wide basis.

Where access permission is required this can be sought from tenant farmers, estate managers/factors, gamekeepers or landowners. If permission is granted by an agent of the landowner, it is always advisable to confirm whether the landowner is aware of the request. It is possible that landowners may want to see evidence of Public Liability Insurance before fieldworkers enter their land, although this would mainly be expected where raptor surveys are being undertaken on a commercial basis. In the UK, any fieldworkers working in a voluntary capacity under a BTO ringing permit, or collecting data for a BTO monitoring scheme are covered by the policy held by BTO (contact the Director of Services at BTO; address in Appendix 2). Raptor Study Groups may also hold Public Liability Insurance on behalf of their members and fieldworkers are advised to check on this if necessary before taking out their own insurance.

Fieldworkers are advised to respect reasonable requests to avoid areas where there is potential for conflict with land management, and to be particularly considerate if working at very early or late hours, or close to residential properties.

7.2 Minimising disturbance and good field craft

As with any survey and monitoring fieldwork, the welfare of the birds is of maximum priority. Fieldworkers should be aware that their presence may cause disturbance to the birds that they are surveying, and should not undertake fieldwork that might adversely affect the survival or reproductive success of birds.

Disturbance at or close to a nest may cause birds to abandon a breeding attempt. Advice is given in each species account on the appropriate timing and manner of visits to nest sites to minimise disturbance. However, some general principles apply to most if not all species of birds of prey. These include being particularly careful just prior to and during laying, and during early incubation, as many species are particularly sensitive and may desert their nests if disturbed at this time. At all times, nests should only be approached as closely as is necessary to obtain the information that is required, and species-specific advice should be followed regarding safe distances through the breeding cycle. It is important to minimise disturbance of vegetation around nest sites as this can lead predators to the nest or render the nest more exposed to the elements. Especially for species which may be vulnerable to wildlife crime, it is also important that the fieldworker ensures that they are not being watched, so as not to lead potential human 'predators' to the nest. Incubating or brooding birds that are flushed during visits to nests may dislodge eggs or small young from the nest cup. Any such misplaced eggs or young should be carefully replaced to ensure that they are incubated or brooded properly when the adult returns.

When carrying out watches from a distance, neutral coloured clothing should be worn and use made of natural or man-made shelter for concealment whenever possible. Advice on appropriate distances from nests for vantage point watches is provided in the species accounts (see also Section 3 of the introduction to species accounts). If birds exhibit alarm calls/behaviour, leave a nest site, or fly repeatedly around a particular area, apparently aiming to land but aborting at the last minute, this suggests the fieldworker is too close and should move away as quickly as possible to a distance at which agitated behaviour ceases. If the nest

can be watched from a safe distance, a check should be made to see whether the bird returns. If this cannot be done without further disturbance, or if the bird does not return in a short time, the fieldworker should leave the area completely and not return that day. Any further visits to the site should be made in an appropriately cautious manner.

Reactions to disturbance vary between raptor species and also between individuals of given species. It is useful to keep a record of nests where disturbance events occur and the overall outcome of these nesting attempts. Such records can be used to assess the risk of monitoring the species in question and allow further precautions to avoid disturbance to be taken in subsequent years.

7.3 Weather

Observers should not disturb birds in adverse weather (i.e. cold, wet or excessively hot conditions; Greir & Fyffe, 1987). In particular, eggs and small chicks that are still being brooded are very susceptible to chilling or overheating if the adult bird is flushed from a nest. Predators of eggs and chicks may also be more stressed in such conditions and might move in quickly if the nest is left unattended even temporarily by the adult birds. Unfavourable weather (e.g. a prolonged spell of snow) during laying in particular, but also later in the breeding cycle, might place energetic strain on the adults and any additional disturbance at such a time might be more likely to bring about desertion than if weather conditions are favourable.

Fieldworkers should be aware that weather conditions may affect their observations (Robbins, 1981), especially when searching for displaying birds that tend to be more active in good weather; many species will display most actively on fine but slightly breezy days. Nocturnal species that are surveyed by calls may be more likely to call on clear, dark, dry nights than on wet nights (e.g. Ruggieri, 1995; Lengagne & Slater, 2002) and calls will be difficult to hear in strong wind.

7.4 Time of day

The activity patterns of birds of prey vary between species and through the breeding season (e.g. Fuller & Mosher, 1987). However, as a general rule, diurnal birds of prey tend to be more active in the morning and evening than during the middle of the day, and are therefore more detectable at those times. Whenever possible, guidance on the most appropriate times of day to carry out observational work based on the known activity patterns of each species is given in the individual accounts in this book. The time of day for surveying and monitoring may be particularly important for crepuscular species (for which the window of opportunity for making visual observations may be restricted) and for nocturnal species. If there is a need to disturb a nocturnal species at the nest or at a roost during the daylight hours, this should be done as close to dark as possible, so that the birds can return to the nest under cover of darkness or are not exposed to predation or mobbing (behaviour intended to drive away rather than capture a target bird) while looking for an alternative roosting site.

7.5 Frequency of site visits

When surveying birds of prey, the frequency with which visits need to be made to sites depends on the particular aims of the work. If the aim is to determine the number of occupied home ranges or nesting ranges within a study area, then it will usually be necessary to visit some sites on at least two occasions, if evidence for occupancy is not found at the first visit. The first visit should generally take place early in the breeding season, before laying if possible, to ensure that pairs that occupy a site but fail to lay, or fail early in incubation, are not missed. Many birds of prey are difficult to locate during incubation and for some species, only visits

later in the season to record the presence of an active nest or vocal young, for example, will give rigorous confirmation of occupation (or lack of occupation).

If the aim is to record breeding success, then further visits are required in addition to those for establishing occupancy. At a minimum, one further visit will be required to look for fledged young and establish whether breeding has been successful. In practice, however, two or more additional visits may be required to verify the presence or absence of fledged young (if no young are found on the previous visit), or to count young in a nest prior to fledging (because they are more difficult to count once they leave the nest).

Guidance on the numbers and timings of visits that may be required for assessing occupancy and breeding success for each species is provided in the individual species accounts. Additional, appropriately timed visits may also be made if the aim is to collect information to confirm laying, clutch size, hatching and initial brood size. More frequent visits can also identify the stage (and perhaps the cause) of breeding failure if this occurs. The ideal timing of such visits varies between species and is discussed in the individual species accounts.

7.6 Observer effort

This is a measure of the amount of time spent and ground covered by a fieldworker during survey and monitoring work. There are several important components to this with respect to raptor surveys: the total area covered; the number and timing of visits; and the duration of visits.

It is important that the area searched for the target species is defined accurately. This allows comparisons to be made between the numbers of home ranges or nest sites that have been checked and/or located in different years, and also means that the representativeness of the sample in relation to the population as a whole can be assessed. Information on the ground covered in each year should be recorded onto maps of the study area. It is also very useful to record details of the effort in terms of the number of visits to different parts of the study area.

The time that needs to be spent observing at each visit will depend on a number of factors, including the species, likely stage of breeding, ease of observation of the site or area in question and weather conditions. Guidance is provided for each species in the individual accounts. It is important to record the start and end times of each visit and each watch at any given nest site or area, so that effort can be quantified in this respect.

Recording observer effort allows for the identification of sites that have received sufficient survey visits at appropriate times of the breeding season, and of appropriate duration and time of day, to record observations of a target species. Importantly, recording of survey effort allows the identification of 'nil returns' from areas where no birds are found despite appropriate survey coverage.

7.7 Recording observations and site features

Details of the timing and routes taken during survey visits, and each observation of a target bird of prey species, nest or other distinguishing sign, should be recorded in the field along with a map reference at the appropriate spatial scale. The basic equipment required is a pair of binoculars, a map and a notebook. A compass and/or handheld GPS unit are also recommended.

It is recommended that fieldworkers record observations in a notebook. Such notes may usefully be supplemented by marking the area covered during the field visit, and the locations of observations (e.g. the path of a flying bird), on a photocopied map of the survey area at an appropriate scale. For some species, standardised recording forms have been developed for the submission of data for national surveys (examples are included in Appendix 3). Raptor workers may wish to carry and complete similar forms while they are undertaking fieldwork or design their own forms for other specific purposes. It is recommended, however, that a notebook is also carried for any supplementary information or observations for which there may not be enough space on the form. In some cases, where the observations may form part of the basis for statutory designations to protect sites, or as evidence for wildlife crime, reference to original field notes may be required, so it is important that these are as clear as possible and include details of locations and dates. Electronic recording devices such as hand-held computers or dictaphones may also be used to record observations. These may have the advantage of enabling fieldworkers to record information more quickly, but it is advisable always to carry a notebook as a back-up, in case a device becomes damaged or the battery fails. In addition, it is recommended that any information recorded directly into an electronic device is downloaded and backed-up (e.g. through transcription, storage on a computer and printing a paper copy) as soon as possible.

Recommendations on the specific information to be recorded for each observation of a bird, nest or other sign, and during each field survey visit are given below. In addition, an annotated list of the information that contributors to the Scottish Raptor Monitoring Scheme are asked to submit for each site record (in this context a site refers to an individual home range of a given raptor species during the breeding season) is included in Appendix 3. Central to all of this is the recording of accurate map references using the National Grid for each country. This can be done from a map of an appropriate scale or using a GPS. The Ordnance Survey produce a useful free leaflet with guidance on taking map references and other tips on using maps (see www.ordnancesurvey.co.uk or available in most bookshops that stock OS maps). GPS units are now widely available and affordable and are recommended, both for safety reasons and for accuracy – because many of the habitats and landscapes where birds of prey occur, such as open moorland or woodland, may have limited features of use for pinpointing a location. In addition to their use for recording locations, many GPS units allow the grid references of specific points and the routes taken by an observer on a survey trip to be recorded. For the purposes of recording raptor observations, the guidance below specifies four or six figure grid references – which give locations respectively to the nearest 1 km or 100 m. Many GPS units provide ten figure grid references (locations to the nearest metre) and it is useful to record these but it should be remembered that the accuracy of devices may vary, for example with weather conditions.

7.7.1 Recording sightings of birds, nests or other signs

A list of the recommended features to record for each observation of a bird, nest, or other sign is given in Table 1 below. Generally in raptor fieldwork, sightings of birds and other signs are relatively infrequent and there should be sufficient time to record all of the recommended features. If sightings of birds are very frequent, for example in a high density breeding population or at a winter roost, then it may not be possible to record all details for every sighting. Fieldworkers will then have to decide which features are most important in terms of the objectives of their study and focus on these. In such cases it should be noted that some features, such as location and habitat, may be common to a number of sightings, and can be recorded as such. At roost counts the recording of cumulative counts of birds over time intervals may be appropriate.

Locations should be recorded as accurately as possible, using a six figure grid reference wherever feasible, for example for a perched bird, a bird displaying in a restricted area, a specific aspect of behaviour such as a food pass, or a fixed object such as a nest. A four figure reference may be more appropriate for a bird observed in flight or displaying over a large area.

Table 1. Features to record whilst observing raptors.

Feature	Notes
Full description of the observation	Species and numbers of bird(s) seen or heard
Description of nest or other sign (pellet, kill, feathers etc.)	A sketch and/or digital photograph of the location of a nest or other sign in relation to nearby features can be helpful for relocation at a later date
Sex and age	Of any bird(s) seen or heard, if distinguishable, and any features that might aid individual identification (wing tags, missing wing or tail feathers, unusual plumage features, etc.)
Behaviour and calls	Display, food pass, alarm call, etc.
Nest contents (number of eggs and/or chicks)	Including any measurements of eggs or chicks and details of any rings or other marks placed on chicks
Date and time	24 hour clock recommended
Location	six or four figure grid reference (or more accurate reference from GPS)
Habitat	For the area where the observation was made or in which the nest or sign was located

Recording the behaviour of any birds observed is important because it can provide evidence of territoriality and/or the stage of breeding. The species accounts include specific recommendations on important behaviours to record for individual species, which may include calling, alarming, chasing or aggression towards conspecifics or other species (birds, humans or other mammals), displays, carrying food and food passes.

Raptor nests are often well concealed and once found, may be difficult to relocate from a grid reference alone, especially if the nest is observed from a distance (e.g. on a cliff ledge). It is therefore recommended that a sketch of the position of any nest is made in a notebook, with details of nearby features that can help with relocation in subsequent visits to ring chicks or record breeding success. Photographing the nest area with a digital camera can also provide a useful record. Photo imaging software can be used to enhance an image and highlight relevant features which can be used to relocate a nest. When identifying such features, however, vegetation growth should be taken into account - features which may be prominent early in the season, may be less conspicuous later on. The location of any vantage point from which a nest is viewed should also be recorded as a six figure grid reference along with a compass bearing for the direction between the vantage point and the nest.

To minimise disturbance, it is recommended that visits to nests to record the contents are kept to a minimum taking into account the aims of the study, the health and safety of fieldworkers (Section 7.10) and requirements for an appropriate licence (Section 7.1.1).

Descriptions of the habitats where observations are made are important in terms of identifying habitat features that influence the distribution, abundance and population trends of raptors. There is, however, no standard system of habitat recording that has been consistently applied to raptor survey work. Fieldworkers wishing to identify appropriate habitat description categories

(e.g. heather moorland, blanket bog, unimproved grassland, plantation forestry, etc.) and/or variables (e.g. height of vegetation around a ground-nest, height of tree-nest above the ground) to record for particular species are advised to check recent publications on that species (including books and scientific papers) for guidance. For rarer species, which are the subject of periodic national surveys within Britain and Ireland (see Section 2.3), the most recent published account of such a survey should include details of any habitat variables identified as important to record during fieldwork. Habitat and land management variables used for reporting under the Scottish Raptor Monitoring Scheme are listed in Appendix 3. Useful advice on the description and measurement of bird habitat is also included in Bibby *et al.* (2000). Participants in BTO ringing or nest recording schemes will be familiar with their hierarchical habitat coding system (Crick, 1992); this is designed to be used by birdwatchers and requires no expert botanical knowledge. It is based largely on vegetation structure but includes simple floristic categories within the broader habitat types. It also includes aspects of land management and human usage, so it covers agricultural and other man-made habitats as well as semi-natural ones.

In addition to the features listed in Table 1 above, it may be appropriate to make additional notes including the location of the fieldworker (as a six figure grid reference) and the distance and direction (compass bearing) between the fieldworker and the bird, nest or other sign that has been observed. Recording the flight direction of a bird carrying prey (as a compass bearing) is also often recommended in the species accounts as a means of identifying the direction in which to search for a nest. If wildlife crime is suspected, then additional features may be noted, as described in Section 7.9 below.

7.7.2 Recording details of survey visits

In addition to the observations above, it is recommended that fieldworkers record specific information about the visit itself for each field survey visit (Table 2).

Detailed recording of the timing and areas covered in individual field visits to a study area is important for interpretation of any survey and monitoring data. As described above (Section 7.6), the number and timing of visits will influence the confidence that can be placed on particular records, for example in deciding whether a site was really unoccupied or whether birds may have been missed due to a restricted number of visits or non-ideal timing. In addition, recording survey routes and particularly the location of good vantage points for watches, will assist with orientation during repeat visits to the same area. It can also be useful to record the area which is visible from each vantage point.

Table 2. Features to record for each site visit.

Feature	Notes
Arrival and departure times	24 hour clock
Area covered	Mark on a map
Route taken	Mark on a map
Location of vantage points from which watches are made	six figure grid reference (or more accurate reference from GPS)
Arrival and departure times at vantage points	24 hour clock
Weather conditions	Cloud cover, wind speed and direction, precipitation, visibility

During initial visits to a survey area, it may be possible to mark on a map extensive areas of habitat that are considered unsuitable for a target species (e.g. dense woodland for a species of open moorland) and that need not be covered in subsequent visits to that area. Depending on the habitats involved, such maps of unsuitable areas may need to be redrawn annually or may be valid for a number of years.

It can also be useful to record weather variables such as cloud cover (the percentage of the sky covered by cloud), visibility, rainfall and wind speed (e.g. for the Beaufort Scale, see www.bbc.co.uk/weather/features/understanding/beaufort_scale.shtml) and direction. The basic weather categories used by the BTO/JNCC/RSPB Breeding Bird Survey provide a useful model (www.bto.org/bbs/take_part/download-forms.htm). Generally it is recommended that surveyors avoid carrying out fieldwork in extreme weather conditions (e.g. strong winds, heavy rain or snow, thick fog) to avoid adverse effects on birds and for health and safety reasons. Where appropriate, the species accounts provide further guidance on any aspects of weather that may have particular influence on behaviour.

7.8 Handling and measuring eggs and young

For many species of raptor, measuring chicks can give a good indication of their age and, in sexually dimorphic species, their sex (see Section 6.5.2 above). For a few species, published information is also available to allow estimation of the hatching date of eggs by measuring their density (Section 6.5.1 above). Handling and measuring eggs and chicks requires care, both to avoid damage to birds or eggs, and to ensure that measurements are taken accurately. Appropriate training to take the measurements described below can be obtained from a raptor worker with experience of handling chicks, or a licensed ringer (and note also the licence requirements in Section 7.1.1 above). Equipment for taking such measurements (wing rule, callipers, spring and electronic balances, bird bags and plastic weighing 'cones') can be obtained from the Ringing Unit at the BTO (contact details in Appendix 2).

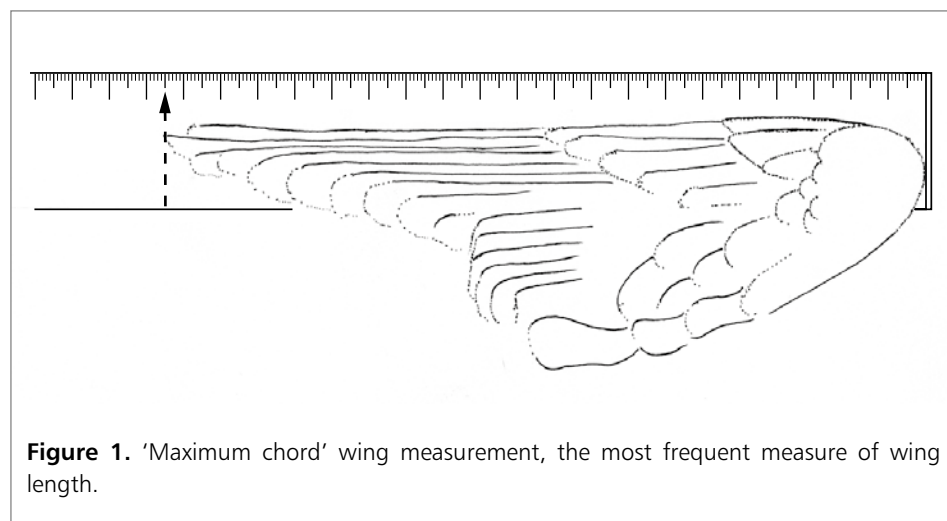
Nest visits should be avoided in adverse weather (cold, wet or excessively hot) and appropriate health and safety precautions should be taken if nest checks require climbing trees or rock faces, or wading through water (see Section 7.10 below). If an adult bird is likely to be sitting (incubating eggs or brooding chicks), then it is a good idea to make a deliberate noise (e.g. snapping small twigs, coughing, muffled talking) when approaching the nesting area to alert the bird to the presence of the fieldworker. Even so, incubating females of many raptor species may sit tight until an observer is almost at the nest. Information on the appropriate ages to ring the chicks of raptor species is given in Redfern & Clark (2001). Well-grown young of some species are prone to jump from the nest if they are approached late in the nestling period and care should be taken not to cause premature fledging, especially with cliff or tree-nesting species. In general visits to crag or tree nests should be avoided once young are fully feathered and have no nesting down on their heads. Chicks with down rarely jump although special care needs to be exercised on dry breezy days as occasionally a well-feathered chick with retained down on the head may be tempted to jump prematurely. Further guidance on specific sensitivities of individual species to nest visits is included in the species accounts.

The removal of raptor chicks from a nest and handling for measuring, ringing and tagging is likely to induce alarm behaviour from the parents, and all procedures should be carried out as quickly as possible. Some species, or individuals of a species, may be aggressive towards fieldworkers handling young and in this case the person ringing or measuring chicks may require an assistant to prevent injury from attacking adults.

The following descriptions of standard measurements for chicks are based on *The Ringers' Manual* (Redfern & Clark, 2001). Small young of raptors can be held in the standard grip used by ringers (Redfern & Clark, 2001). Older young and those of the larger species ideally may require two people present to handle them securely. Such large young can also be handled more safely if a purpose-made falconry hood is used and/or they are provided with an object (e.g. a bird bag or pencil) to grasp in their talons. If it is necessary to restrain a bird by holding the bill shut, the external nares (nostrils) must not be obstructed, to allow it to breathe.

7.8.1 Wing length

Wing length is most frequently measured as the 'maximum chord' using a wing rule. The wing is straightened with all feathers in order, neither crossed nor bent, and is held in, as near as possible, the resting position. The ruler is then placed under the wing, with the carpal ('wrist') joint against the stop ridge (Figure 1) and gently flattened. The feathers are straightened carefully along the ruler and the measurement taken to the nearest millimetre. Before attempting this measurement, fieldworkers should have considerable experience in the technique and should have checked that they can take consistent measurements. Wing length measurements will not be accurate if the feather tips are very abraded (worn) or broken.



For some of the species in this book, ageing and sexing data include measurements of the growth of individual primary feathers rather than the wing itself. Measurements of individual feathers are believed by some to be more repeatable between observers than maximum wing chord, and/or independent of the condition of a chick. Information on taking such measurements can be found in Redfern & Clark (2001), published studies (references in species accounts) and/or through seeking advice from the authors of such studies or experienced ringers.

7.8.2 Tarsus (leg) length

The minimum length is the most frequent method used. This gives the length of the tarsometatarsal bone. The measurement is taken with the leg held at right angles to the tibia (the part of the leg above the 'knee') and the foot held at right angles to the tarsus. The measurement is the distance between the notch of the 'knee' and the foot (Figure 2 (i)). Ideally this measure is taken with callipers but a ruler can be used. Maximum length (tarsus and heel) can also be measured: the tarsus is held in the same way but the measurement is

taken from the distal point at the 'knee' and not the notch (Figure 2 (ii)). A third method of measuring tarsus length may be easier for small chicks. The tarsus is measured from the centre of the 'ball' of the foot to the distal point of the 'knee' (Figure 2 (iii)). The method of measurement should always be recorded. It is recommended that tarsus length is recorded to the nearest 0.1 mm for tarsal lengths up to 100 mm, and to 1 mm if the tarsus measurement is greater than this.

(i). Tarsus measurement.

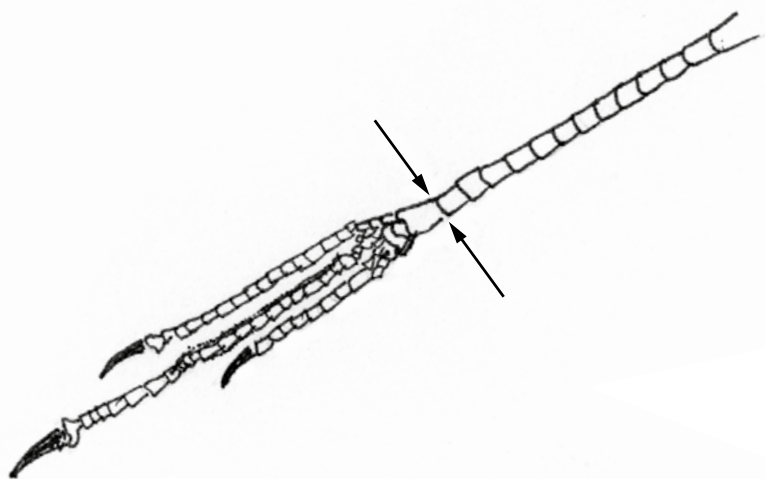
(ii). Tarsus and heel measurement.

(iii). 'Foot' and heel (from 'ball' of foot to heel) measurement.

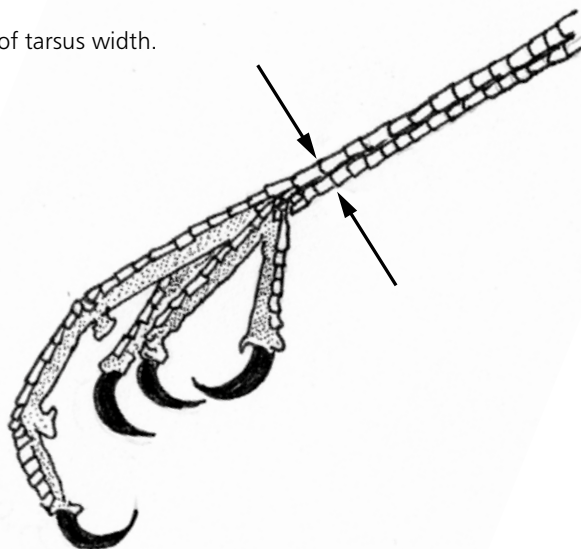
Figure 2. Three ways of measuring tarsus (leg) length. In each case the measurement is the *shortest* distance between the points indicated.

7.8.3 Tarsus width and depth

These measurements are taken using callipers and should be measured to the nearest 0.1 mm. Tarsus width is taken at right angles to the foot at the narrowest point on the tarsus (Figure 3 (i)). Tarsus depth is also taken at the narrowest point of the tarsus, parallel to the foot (Figure 3 (ii)). For standard or maximum measurements of tarsal width and depth, the callipers should touch the scales on the leg but not depress them. For some species, a 'minimum' or 'tight' measurement is recommended (see individual species accounts). This involves using the flat inner jaws of a calliper (not the sharper edges at the outer part of the jaw). While supporting the bird's leg, the callipers are held across the narrow point of the tarsus and the jaws are pressed briefly and firmly (using the thumb of the hand holding the callipers) against the scales to measure a minimum tarsus width or depth.



(i). Measurement of tarsus width.



(ii). Measurement of tarsus depth.

Figure 3. Measuring tarsus width and depth.

7.8.4 Foot span and hind claw

For measuring foot span, the foot is held flat against a ruler. Foot span can be recorded as the length without the claws (Figure 4 (i)) or with the claws (Figure 4 (ii)), and observers must record clearly which measurement is taken. Foot spans up to 100 mm should be recorded to the nearest 0.1 mm, and to 1 mm for measurements greater than this. The length of the hind claw (Figure 4 (iii)) can be measured directly with callipers to the nearest 0.1 mm.

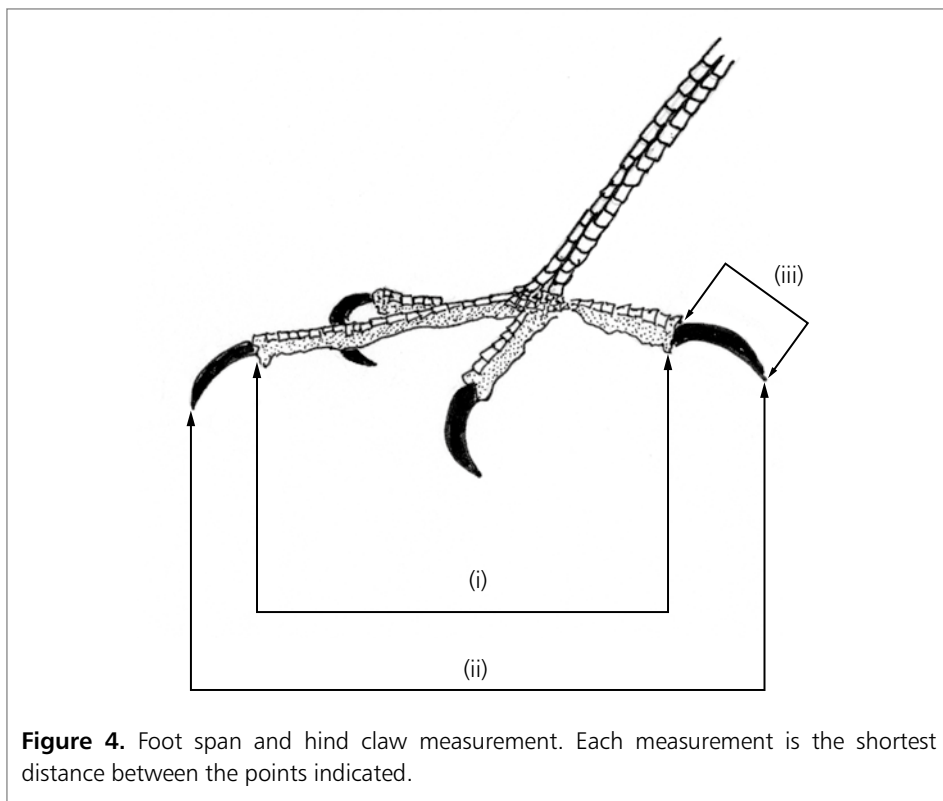
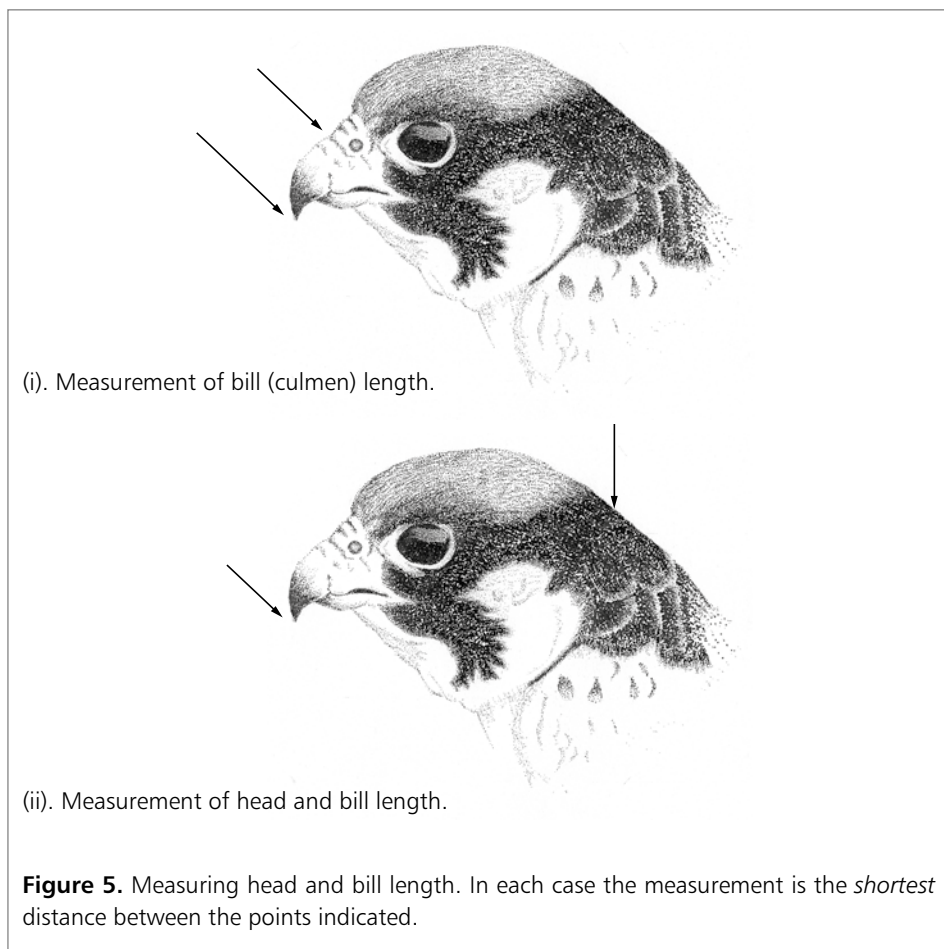


Figure 4. Foot span and hind claw measurement. Each measurement is the shortest distance between the points indicated.

7.8.5 Bill (culmen) and total head length

Bill (culmen) length should be measured to a precision of 0.1 mm using callipers. In raptors, the standard measurement (Figure 5 (i)) extends from the bill tip to the edge of the cere (the bare skin at the top of the bill, between the bill and the facial feathers) on the upper mandible (top half of the bill). If the shape of the bill does not allow access for callipers, the measurement should be made very carefully using dividers and a ruler.

Total head length or head and bill length (from the base of the skull to the tip of the bill) is a valuable measure of body size, and a good sex discriminant in many groups of non-passerine birds, including some raptors. The measurement is taken from the tip of the bill to the back of the skull (Figure 5 (ii)). Carefully bending the head forwards will improve the measurement technique. For total head lengths of up to around 100 mm, the measurement can be taken to the nearest 0.1 mm using callipers. If the measurement is to be taken on a regular basis, then it is useful to thicken the arm of the callipers that rests on the back of the skull (e.g. by gluing a piece of solid material onto either side of the calliper arm). Callipers may be too small for larger birds, in which case the measurement can be taken to the nearest 1 mm by gluing a plastic or metal ruler to a block of solid material and placing a further block of material with a slit cut through it over the ruler. With



the back of the skull placed on the fixed block, the moveable block can be slid up to the end of the bird's bill and the measurement read off the ruler.

7.8.6 Mass

Mass is measured in grams using a spring balance. Each chick should be placed in a cloth bag. Holding the balance by the hook or loop at the top, attach the bag to the hook on the bottom of the balance. With the bag hanging free, the mass is read off the balance. The bag is then weighed again without the chick and its mass is subtracted from the combined mass of bag and chick to give the chick's mass. Eggs and very small chicks (with a weight that is small in comparison to that of the bag) may be weighed in a plastic weighing cone or on portable electronic scales. The weighing device should be sheltered from the wind to ensure an accurate measurement. Balances should be calibrated regularly with objects of known mass to ensure accuracy.

As the mass of an individual bird can vary through the day due to consumption of food, it is important to record the time of day at which birds are weighed. In addition, for raptor chicks, it is useful to record whether there is food in the crop at the time of weighing (see Figure 6), as some existing criteria for distinguishing between the sexes of chicks based on mass rely on a distinction being made between individuals with full and empty crops (e.g. Bijlsma, 1999). Experience may be required to make this distinction for particular study species.

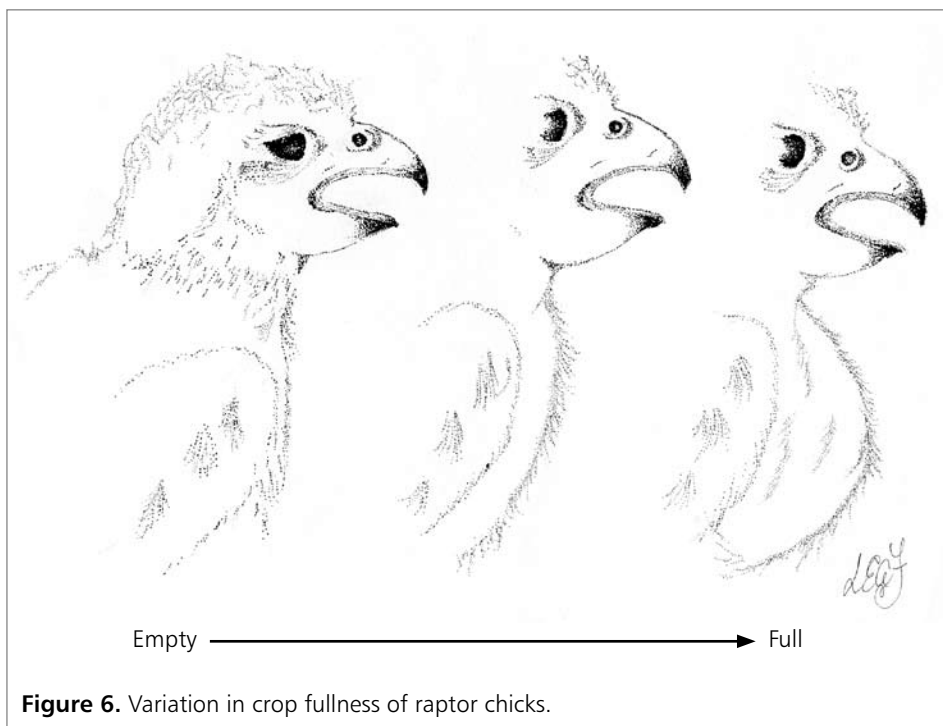


Figure 6. Variation in crop fullness of raptor chicks.

7.8.7 *Measuring and weighing eggs*

Eggs should be measured using callipers. Length and maximum breadth are the two measurements required when calculating density (Figure 7; see also Section 6.5.1). It is best to hold each egg between the thumb and index finger and carefully slide the jaws of the callipers over the part to be measured; take the measurement when the jaws just scrape the shell and always move the jaws when they are slightly away from the egg to avoid damaging the shell. It is a good idea to practise measurements on hens' eggs first, to ensure measurements are repeatable and can be made as quickly as possible. Length and breadth should be measured to the nearest 0.1 mm.

Eggs should be weighed to the nearest 0.1 g. If a spring balance is used, each egg should be placed in a cloth bag or a plastic cone that is at least half as long again as the egg, to minimise the risk of it falling out. If it is windy, measurements can be made most effectively by sheltering the balance and egg (e.g. by lowering into an open rucksack). The balance should be held over something soft rather than rocks, in case it is dropped.

Measuring more than one egg in a clutch will allow a more precise prediction of hatching date from a nomogram. If eggs are being weighed repeatedly for density measurements, they can be carefully marked using a non toxic felt-tip pen so that length and breadth measures need only be taken once. When measuring and weighing eggs to judge the stage of incubation, always first check the blunt end of each egg for any signs of hatching.

7.8.8 *Other measurements*

A range of other measurements may sometimes be taken to age or sex raptors. As these are non-standard, it is important to check the relevant source of reference for details of how they are taken, prior to using them in the field.

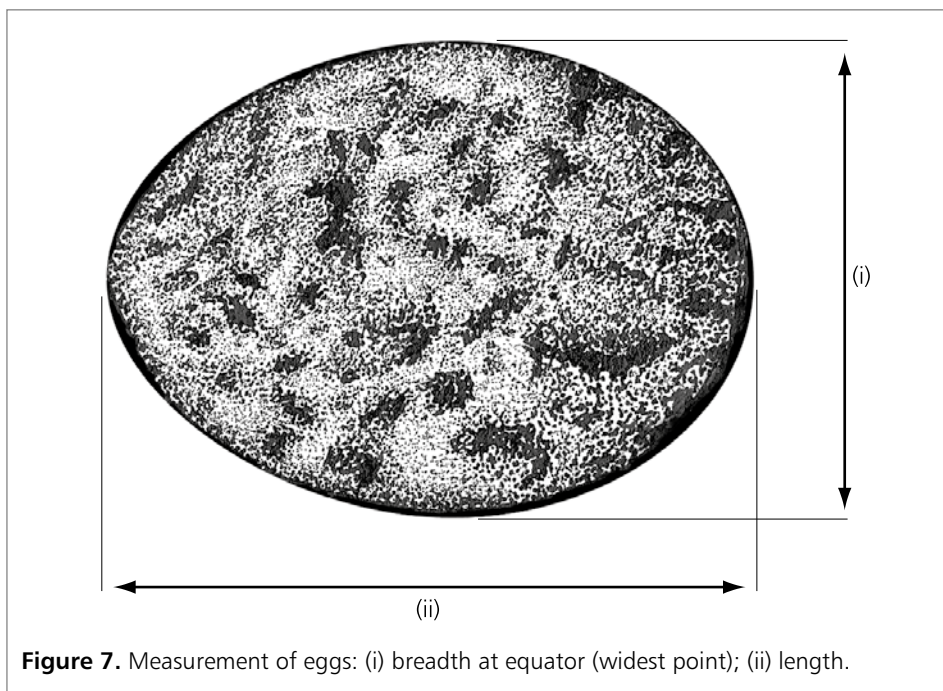


Figure 7. Measurement of eggs: (i) breadth at equator (widest point); (ii) length.

7.9 Wildlife crime

Raptors may be persecuted illegally (Etheridge *et al.*, 1997; Scottish Office, 1998; Anon., 2000; RSPB, 2012a, b; Whitfield *et al.*, 2003, 2004a & b, 2006b, 2008a) through poisoning, shooting, the destruction or taking of nests, eggs or young, or the illegal use of traps. Wildlife crime may also involve actions that result in the intentional or reckless disturbance of birds at their nests or other locations where it is illegal to do so, for example the use of photographic equipment from a hide close to a nest without a licence.

Raptors may disappear from an occupied home range, or fail to breed successfully, for a variety of natural reasons, including bad weather, a shortage of available prey, or predation of eggs, chicks or adult birds. If wildlife crime is suspected, accurate records of any observations or evidence should be made and reported to the Police as soon as possible. It is important not to disturb a suspected crime scene or to destroy evidence that may be invaluable to the Police. When recording incidents, fieldworkers in Scotland should be aware of the principle of corroboration in Scots law, which requires evidence to be accounted for by two sources. Ideally this would involve two eye-witnesses but additional sources of corroboration, such as a photograph or video footage, may be used in addition to the evidence of a single witness. In the specific case of egg theft or destruction, there is provision (Section 19A of the Wildlife and Countryside Act 1981, as amended) for convictions in Scotland on the evidence of one witness.

If a potential wildlife crime incident is observed, then a fieldworker should call the Police as soon as possible and ask for an incident number (this ensures that a record will be made of the report). Any observed or suspected perpetrator of an incident should not be approached. Rather, notes should be taken, including a full description of the suspect with details such as clothing, actions, words spoken, and whether the suspect is known or has been seen previously. Notes should also be made of the location of the observation point, the distance of the suspect from the observation point (and any obstructions that interrupt the line of view), whether or not optical

aids were used, and details of light and weather conditions. In addition, if a suspect is observed using a vehicle, then the registration number, make, model and colour should be noted.

If there is evidence of suspected persecution, the exact location (a six figure or more accurate GPS grid reference) should be recorded, along with full details of the evidence. If possible, the scene should be photographed or videotaped. Inclusion of an object of recognisable size (such as a pen or a coin) in a photograph, for example of a footprint, will help to indicate scale.

Evidence of persecution may include: the carcasses of poisoned or shot birds of prey; poison bait; the poisoned carcasses of other birds or animals in locations or circumstances that indicate that raptors may be at risk; or traps set illegally.

Some of the poisons used are extremely toxic to people (and dogs), so suspected poisoned bait or victims of poisoning should not be touched. Instead, carcasses should be covered if possible (without destroying evidence) until the Police or other authorised persons can retrieve them for analysis. The Police should be informed of the location of the suspected poison as soon as possible.

Fieldworkers are advised to be aware of and respect the legal use of traps and snares. Sources of information include: the Game and Wildlife Conservation Trust's book on predator control (Game Conservancy, 2005); codes of practise (including fox snaring and traps for pest birds and mammals) published by the British Association for Shooting and Conservation (www.basc.org.uk); and the Partnership for Action Against Wildlife Crime (PAW), a multi-agency group comprising representatives of all of the organisations involved in wildlife law enforcement in the UK (www.defra.gov.uk/paw).

The general rule is to leave evidence – such as a trap, cartridge cases or a cigarette packet – *in situ*. With such items, it is DNA evidence that is likely to be of most use to the Police and handling may result in contamination by the DNA of the fieldworker. In this context, it is good practice for fieldworkers to ensure, when they visit a nest or observation point, that they do not leave any items (e.g. chewing gum or cigarette ends) that could confuse a possible future crime scene. Unless it is possible to await the arrival of the Police, it is recommended that an illegally set trap should be photographed or video-taped in the set position and then sprung with care using a stick. This is to avoid further danger to people or wildlife.

On leaving the scene of an incident, fieldworkers are advised not to discuss their findings with anyone they encounter in the area, to minimise the risks that evidence might be removed or altered.

When reporting incidents to the Police in England, Scotland, Wales, and the Isle of Man, the local Police Wildlife Crime Officer (PWCO) should be informed, and can be contacted through any Police Headquarters. In Northern Ireland the local police should be contacted. In the UK, RSPB investigations officers (www.rspb.org.uk/policy/wildbirdslaw) work closely with the Police and others involved in the investigation of wildlife crime, and can provide useful advice on wildlife crime incidents. They can be contacted through any RSPB office or incidents can be reported online (www.rspb.org.uk/ourwork/policy/wildbirdslaw/report.aspx). Staff of Statutory Country Conservation Agencies can also provide advice on wildlife crime and initial enquiries can be made to any office. Further information on reporting wildlife crime incidents in the UK can be obtained from PAW (www.defra.gov.uk/paw). Wildlife offences in the Republic of Ireland should be reported to the local NPWS Conservation Ranger (www.npws.ie) or to the local Garda (Police) station.

7.9.1 *Site confidentiality*

Because raptors may suffer from persecution by humans, it is common practice, for some species, to keep information on the locations of nest sites, or of territorial birds, confidential, and to store them securely. Fieldworkers are advised not to pass on information on the location of nest or roost sites, especially of scarcer species, in any circumstances where there is a suspected risk to the birds.

Raptor data, such as the locations of nest sites, regular flight paths and roosting areas, are increasingly of use for conservation purposes. These include the designation of protected sites such as Special Protection Areas (EU Birds Directive) and Sites of Special Scientific Interest, and environmental impact assessments for proposed developments such as windfarms. Contributors to the Scottish Raptor Monitoring Scheme are asked to provide locational data for nest sites as six figure grid references. It is also very useful if site location information is routinely provided to the Statutory Country Conservation Agencies on licensing report forms, to the RBBP and to the BTO as part of ringing or NRC returns. Such information is kept strictly confidential and stored in a secure database along with details of the data provider and/or owner; it can be made available, with appropriate permission, for conservation and site safeguard purposes. Complete secrecy can be counter-productive, as sites have been lost, destroyed or disturbed because the relevant conservation agencies were not aware of them until too late (e.g. Spencer & RBBP, 1992).

7.10 Health and Safety

This section contains notes on good practice that raptor surveyors may find helpful to consider before undertaking fieldwork.

Field surveys of raptors may involve visits to remote areas of countryside by lone workers. Checking nests and ringing chicks may require climbing trees or cliff faces. Birds of prey and their chicks can be aggressive and larger species in particular have the potential to inflict serious wounds on handlers. It is good practice for raptor surveyors to consider the potential risks to their own health and safety while they are undertaking fieldwork, and to take appropriate actions to minimise these risks, for example, by: carrying and ensuring they are able to use suitable equipment for navigation and communication; wearing appropriate clothing for protection against adverse weather; carrying adequate supplies of food and water and a basic first aid kit. Similarly, it is good practice for fieldworkers to consider the health and safety of others who may be affected by their actions, and to pass on relevant health and safety information to those accompanying them on survey work.

When visiting remote locations, it is important to leave a note of the trip with a responsible person. This should include: the date and time of departure; the method of travel to and from site; the proposed itinerary; the expected time of return; vehicle identification; details of who to contact in the event of failure to return; and the appropriate time to raise an alarm. It is advisable to carry a mobile phone for emergency use (but note that it may not work in some remote areas).

Hypothermia is a significant hazard when working in exposed environments such as mountains and moorlands, especially where fieldwork may involve long periods of inactivity during vantage-point watches. It is advisable for fieldworkers to ensure that they have appropriate warm and waterproof clothing and supportive footwear, plus a survival bag and high-energy food supplies. Sun exposure is also a concern, and it is recommended that sun cream of an appropriate sun protection factor is worn at all times on areas of exposed skin.

When working during darkness, it is advisable to carry a torch and spare batteries, wear bright clothes if working or accessing areas along roads, and avoid working alone if possible. It may be appropriate to inform the local Police and/or local residents about your activities and area of operations.

Wild animals or birds should be avoided at certain times of year or in certain situations when they may attack people perceived as intruders; this may include the birds of prey that are the subject of the survey (further advice is given in the species accounts) or, depending on the habitat, rutting deer or large nesting birds such as great skuas. Fieldworkers are also advised to take special care if survey work brings them into close proximity to livestock and other domestic animals (including farm dogs), and agricultural machinery or forestry operations. In addition, warning signs for hazardous sites, such as quarries, ravines or railways, should be heeded.

Before undertaking any fieldwork that involves climbing rocks, cliffs or trees, fieldworkers are strongly advised to undertake training in that activity, and in the use of appropriate safety equipment, such as helmets, harnesses and ropes. The Health and Safety Executive (HSE) publishes a number of useful leaflets, for example: AFAG401 *Tree Climbing Operations* (available from www.hsebooks.com).

Fieldworkers who handle birds of prey are at risk of injury, especially from larger species, including cuts from sharp bills and penetrating injuries from powerful claws. Protective gloves (e.g. those used by falconers) should be worn when handling birds with talons whenever possible, and immunity to tetanus maintained. Particular care should be taken to avoid injuries to the eyes and safety spectacles should be used when working with some raptors, particularly owls (see advice in species accounts). Watch out for wasps, hornets and fleas if work involves opening nest boxes or checking other nesting cavities. It is strongly recommended that any fieldworker without experience of close approaches to raptor nests or handling chicks undertake training in appropriate procedures with someone who is experienced in handling raptors (and indeed evidence of such training will be required to obtain an appropriate licence – see Section 7.1.1). Similarly, a fieldworker with experience of handling birds, who wishes to undertake work on a new raptor species, is advised to consult with a raptor worker with experience of that species.

7.10.1 Diseases

Raptor fieldworkers may be exposed to disease during survey work and ringers are particularly vulnerable because of direct contact with wild birds. If a disease is suspected, then it is important to inform the doctor of possible exposure to zoonoses (diseases of animals that can be transmitted to humans), specifying that nest visiting and ringing have been carried out if appropriate. Typical diseases that may be encountered are as follows:

- Tetanus, which may result from the infection of even minor wounds and scratches with *Clostridium tetani*, a common micro-organism in soil and likely to be carried on talons and beaks. Fieldworkers are advised to ensure that they are immunised against tetanus and that their immunity is maintained by boosting at the appropriate intervals. This can be arranged through a local GP or Health Centre;
- Weil's disease, a severe form of leptospirosis that can be fatal if left untreated. The pathogen is carried by rats and excreted in their urine, and persists in water such as in puddles in rat-infested places. Thus visits to the nests of rat-eating species or in buildings or other locations where rats might occur may pose a risk;

- Lyme disease or Lyme borreliosis, a bacterial disease caused by *Borrelia* spirochaetes transmitted by animal ticks and associated with rank vegetation. The disease is treatable but can cause severe symptoms if left untreated. A variety of animals may act as hosts ranging from sheep and deer in the uplands, to pheasants in some lowland areas of Britain, and on the Continent *Borrelia* spirochaetes have been found in passerines such as blackbirds;
- Tick-borne encephalitis, a viral disease carried by animal ticks. Warm forested parts of Europe and Scandinavia, especially where there is heavy undergrowth, give the greatest risk from ticks in late spring and summer. A vaccine is available where prolonged exposure in the risk areas is likely. In Britain and Ireland, a related virus responsible for 'louping ill', a disease with symptoms varying from a mild flu-like illness to more severe disease requiring hospitalisation, can infect a wide variety of mammal and bird hosts, particularly grouse and hares, in moorland regions; and
- Salmonellosis is a bacterial infection common in rats and mice (which may be found in the 'larders' at raptor nests), which can in certain circumstances spread to the birds as well. The bacteria abound in the droppings of the infected bird, which may not necessarily appear sick. If the bacteria are ingested, for example as a result of preparing or eating food with contaminated hands, there is a risk of food poisoning.

There are other groups of bacteria and viruses to which the same remarks apply:

- Other pathogenic bacteria that may be present in wild birds (often from human-contaminated sources in the first place) include *Campylobacter jejuni* and potentially pathogenic strains of *Escherichia coli*. These could be found at nests of carrion-eating raptors; and
- Avian influenza: numerous strains of avian influenza viruses circulate in wild birds but most are relatively benign. All bird species are thought to be susceptible. Migratory birds such as wild ducks and geese can carry the viruses, often without any symptoms of illness, and show the greatest resistance to infection. People can become infected with avian flu as a result of close contact with infected birds, but this is rare. Historically, human infection with avian influenza viruses has usually caused mild conditions such as conjunctivitis (eye infection) and mild flu-like symptoms. More severe infections can lead to pneumonia, acute respiratory distress, viral pneumonia, and other severe and life-threatening complications. A highly pathogenic strain of avian flu, H5N1, is currently a cause of worldwide concern and can infect raptors. Up to date guidance on this issue in Britain and Ireland can be obtained through the websites of the Statutory Country Conservation Agencies and/or Government Environment Departments and advice for ringers and nest recorders is available on the BTO website.

There are a number of ways in which the risk of diseases can be minimised, such as:

- Immunisation against tetanus and poliomyelitis;
- Removal of ticks from the skin as soon as possible; tucking trouser bottoms into socks so that ticks cannot attach or climb up the leg, and making regular checks of skin and hair; light coloured clothing can make ticks more visible (but may conflict with requirements for fieldworkers to wear neutral or dark colours for concealment);
- On extended fieldwork sessions, remember the need for adequate food, sleep and dry clothing. Self-neglect lowers the body's resistance to any infection;
- Anti-bacterial hand gels can be carried in the field and used to clean hands (particularly after handling birds, soiled bird bags and pellets); in particular, do not touch food with bare hands before washing them and note that a cigarette can transfer infection from hands to mouth; hands should be washed with soap and water and/or detergent after fieldwork.

- During fieldwork, cuts and abrasions should be kept covered by a dressing; and
- Wear disposable rubber gloves when cleaning out nest boxes or handling dead birds, and dispose of the gloves responsibly after use.

7.10.2 *Health and Safety Legislation and Responsibilities*

This section provides some information on legislation covering health and safety that applies to fieldworkers, and gives sources of further information. The details are most relevant to fieldworkers carrying out studies in Great Britain with references provided for relevant sources of information for Northern Ireland, the Republic of Ireland and the Isle of Man.

Those who undertake fieldwork in their own time on a voluntary basis are responsible for their own health and safety. Fieldworkers who contribute data on a voluntary basis to schemes that monitor birds, such as the Scottish Raptor Monitoring Scheme, are also responsible for their own health and safety. This includes schemes where fieldworkers may receive some support, for example travel expenses, for their survey work, as long as they are not actually paid a salary for the work (i.e. they are not employees or agents of the organisation(s) providing the expenses).

Volunteer fieldworkers should not put themselves in a position that could place them, or others, in danger, or undertake any work for which concerns exist about their own or others' health and safety. Volunteers under 18 years of age who wish to participate in fieldwork for a monitoring scheme should ensure that the organisers are aware of their age and have made them aware of the associated risks. They should also ensure that their parents agree to them undertaking the activities. The BTO provides a useful leaflet giving general health and safety guidance for volunteers involved in its work (www.bto.org/volunteer-surveys/taking-part/health-safety).

Fieldworkers who undertake raptor surveys on a professional basis come under health and safety legislation. In England, Scotland and Wales, the Health and Safety at Work Act 1974 works on the principle that those who create risk from work activity are responsible for the protection of workers and the public from any consequences.

If a fieldworker is employed by an organisation to carry out raptor surveys, then the employer has a general duty to provide systems of work that are, so far as reasonably practicable, safe and without risk to health. A safe system of work may be defined as that which results from a systematic examination of a task in order to identify all the hazards, a so-called risk assessment (e.g. see HSE Guide: *Five Steps to Risk Assessment*), and which identifies safe methods of work to ensure that any hazards are eliminated or minimised.

In circumstances where a fieldworker is self-employed and carries out fieldwork under a client/contractor relationship, both parties have duties under health and safety legislation. Similarly, if a contractor employs sub-contractors to carry out some or all of the fieldwork for a contract, all parties have health and safety responsibilities. The extent of the responsibilities of each party will depend on the individual circumstances of the project. Further information on health and safety legislation and its application can be obtained from the Health and Safety Executive (www.hse.gov.uk).

The Health and Safety at Work Act 1974 is also the main health and safety law in the Isle of Man. Though the primary legislation adopted is broadly similar to that in the UK, there are differences, and the regulations are not the same. Further information on its application can be obtained from the Island's Health and Safety at Work Inspectorate (www.hswi.gov.im).

In Northern Ireland, the relevant legislation is the Health and Safety at Work (Northern Ireland) Order 1978 and further information can be obtained from the Health and Safety Executive for Northern Ireland (www.hseni.gov.uk)

The health and safety regime in the Republic of Ireland is broadly similar to the UK. It is governed by the Safety, Health and Welfare at Work Act 1989, amended by the Safety, Health and Welfare at Work Act 2005; and administrated and enforced by the Health and Safety Authority (www.hsa.ie).

