BEST PRACTICE GUIDANCE FOR HABITAT SURVEY AND MAPPING

2011

By George F. Smith, Paul O'Donoghue, Katie O'Hora and Eamonn Delaney

An Chomhairle Oidhreachta
The Heritage Council

BEST PRACTICE GUIDANCE FOR HABITAT SURVEY AND MAPPING

2011

By George F. Smith, Paul O'Donoghue, Katie O'Hora and Eamonn Delaney

CONTENTS

PART FOUR
PRODUCING AND USING HABITAT SURVEY DATASETS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AA	Appropriate Assessment
ASI	Area of Scientific Interest
BAP	Biodiversity Action Plan
BBS	British Bryological Society
BSBI	Botanical Society of the British Isles
CA	Correspondence Analysis
CCA	Canonical Correspondence Analysis
CORINE	Coordination of Information on the Environment
DED	District Electoral Division
DEM	Digital Elevation Model
DNFC	Dublin Naturalists' Field Club
DoEHLG	Department of the Environment, Heritage and Local Government
DTM	Digital Terrain Model
EASC	Environmental Advisory and Consultancy Services
EcIA	Ecological Impact Assessment
EGNOS	European Geostationary Navigation Overlay Service
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
GIS	Geographical Information Systems
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSI	Geological Survey of Ireland
IEEM	Institute of Ecology and Environmental Management
IEMA	Institute of Environmental Management and Assessment
IG	Irish National Grid
ITM	Irish Transverse Mercator
JNCC	[UK] Joint Nature Conservation Committee
NGO	Non-Governmental Organisation
NHA	Natural Heritage Area
NIEA	Northern Ireland Environment Agency
NMS	Non-metric Multidimensional Scaling
NPWS	National Parks and Wildlife Service
NRA	National Roads Authority
NSNW	National Survey of Native Woodland
NUI	National University of Ireland
NVC	[British] National Vegetation Classification
OPW	Office of Public Works
OSi	Ordnance Survey Ireland
OSNI	Ordnance Survey Northern Ireland
PCA	Principal Components Analysis
pNHA	Proposed Natural Heritage Area
SAC	Special Area of Conservation
SPA	Special Protection Area
TWINSPAN	Two-Way Indicator Species Analysis

ACKNOWLEDGEMENTS

The Heritage Council is extremely grateful for the assistance of the many people who gave freely of their time to facilitate the production of this guide. Without their assistance, this publication would not have been possible.

The Steering Committee members were: Cliona O'Brien, Naomi Kingston (NPWS), Gemma Weir (NPWS) and Sharon Casey (Cork County Council). Deirdre Lynn, Rebecca Jeffrey, Robert Ovington and Marie Dromey also provided valuable input (NPWS). Atkins (Ecology) was commissioned to draft this Guidance. Dr Séamus Coveney (NUI Maynooth) made valuable contributions to the design of the project.

We are particularly grateful to those who reviewed and provided helpful comments on an earlier draft of this Guidance: Muiris de Buitléar (DoEHLG); Paul Corbett and Mark Wright (NIEA); Julie Fossitt (NPWS); Tom Gittings (Ecological Consultant); Liam Lysaght (National Biodiversity Data Centre); Jim Martin, Simon Barron, Brendan O'Hanrahan, Fionnuala O'Neill and Philip Perrin (BEC); Richard Nairn, Carmel Brennan, Elaine Dromey, Katharine Duff, Maeve Flynn, Ciara Hamilton and Andrew Speer (Natura); Mary Tubridy (Mary Tubridy and Associates); Judith Vonhof (Cork County Council); and those who reviewed an earlier draft of this document on behalf of the Institute of Ecology and Environmental Management (IEEM): Aebhín Cawley (Scott Cawley); Patrick Crushell (Wetland Surveys Ireland); Mieke Muyllaert (Mieke Muyllaert and Associates); Jenny Neff (EACS); and Roger McNaughton (Tobin). Thanks are also due to Roberta Reeners for her careful editing of the document.

This Guidance is based in part on *Habitat Survey Guidelines: A Standard Methodology for Habitat Survey in Ireland* prepared by Natura Environmental Consultants for the Heritage Council (first draft 2002; second draft 2005).

We sincerely thank all those who responded to a consultation questionnaire developed to assist in preparation of this Guidance:

Conor Kelleher	Aardwolf Wildlife Surveys
Dave Allen	Allen and Mellon Environmental
Alex Copland and Sinead Cummins	BirdWatch Ireland
Simon Barron, Fionnuala O'Neil and Philip Perrin	Botanical Environmental and Conservation Consultants (BEC)
Vicki O'Donnell and Ned Dwyer	Coastal and Marine Resources Centre, University College Cork
Gearoid Ó Riain and Andrew Day	Compass Informatics
Judith Vonhof	Cork County Council
Sharon Casey	Cork County Council
Caroline Hurley	Ecological Consultant
Mark McCorry	Ecological Consultant
Neil Foulkes	Ecological Consultant
Róisín Nash	Ecological Consultant Services (EcoServe)
Paul Murphy	EirEco Environmental Consultants
Anita Hogan	Entec UK Ltd
Mike Lush	ExeGesIS SDM
Orla Fahy	Forest Service
Karina Dingerkus	Giorria Environmental Services
Úna Cosgrave-Hanley	Kerry County Council
Bridget Loughlin	Kildare County Council
Catherine Casey	Laois County Council
Louise Collier	Mayo County Council

Dervla O'Dowd	McCarthy Keville and O'Sullivan – Planning and Environmental Consultants
Louise Scally	MERC Consultants Ltd
Mieke Muyllaert	Mieke Muyllaert and Associates
Ger O'Donohoe	Moore Group Environmental Services
Colin Kelleher	National Botanic Gardens
Noeleen Smyth	National Botanic Gardens
Diane Armitage, Kieran Buckley and Des Crofton	National Grey Partridge Conservation Project
Marie Dromey	National Parks and Wildlife Service
Maurice McDonnell	National Parks and Wildlife Service
Naomi Kingston	National Parks and Wildlife Service
Neil Lockhart	National Parks and Wildlife Service
Caroline Sullivan	National University of Ireland Galway
Keith Kirby	Natural England
Padraic Fogarty	Openfield Ecological Services
Mathieu Lundy	Queen's University Belfast
James Moran	Teagasc
Jenni Roche	Trinity College Dublin
Maria Long	Trinity College Dublin
Paddy Sleeman	University College Cork
Roslyn Anderson	University College Cork
Tom Gittings	University College Cork and Ecological Consultant
Jerome O'Connell	University College Dublin
Patrick Crushell and Peter Foss	Wetland Surveys Ireland
Joanne Allen-Hamilton	White Young and Green (WYG)
Declan Little	Woodlands of Ireland

We appreciate the time spent and insight provided by a number of other people who assisted the project team in many different ways. These include Frank Barrett (Forest Service), Colin Bray (OSi), Anthony Corns (Discovery Programme), Stephen Curran (OSi), Lisa Dolan (Ecological Landscape Design Consultants), Declan Doogue (DNFC), Fernando Fernandez Valverde (Ecologic Consultants), Julie Fossitt (NPWS), Tom Gittings (consultant ecologist), Gareth John (DoEHLG), Paula Kearney (RPS), Liam Lysaght (National Biodiversity Data Centre), Sue Murphy (Ecologic Consultants), Mieke Muyllaert (Mieke Muyllaert and Associates), Richard Nairn (Natura Environmental Consultants), Colm O'Kane (Coillte), Ciara Allen, Vincent O'Malley (NRA), Fiona O'Rourke (EPA), Linda Yost and Jason Reeves (IEEM),Tim Ryle (consultant ecologist), Louise Scally (MERC Consultants), Gerry Sharkey (BSBI), and Edwin Wymer (NPWS).

We are grateful to all the local authority Heritage and Biodiversity Officers who provided copies of habitat surveys they have commissioned and who provided useful insight and discussion at a Heritage Council seminar.

FOREWORD

This publication provides best practice guidance for habitat survey and mapping in Ireland, and is predominantly aimed at the professional ecologist who may be managing or undertaking such work, as well as those who may commission it.

The Heritage Council hopes that the application of the guidance in this best practice document will greatly contribute to the achievement of high-quality habitat maps in Ireland. Such maps can and should be used to inform long-term or forward-planning decisions and to support national policies and initiatives. Such decisions have significant impacts on our communities, our landscape, our environment, and our quality of life. Choices made on the basis of such maps – or, even more significantly, in their absence – also affect the ecosystem services that our natural heritage provides to us on a daily basis. It is only in recent years that this is beginning to be more fully recognised and appreciated. The Heritage Council believes that this publication will be an important step forward in the production of high-quality information that can then be fully integrated into decision-making processes, for the benefit of our communities and our heritage.

In publishing this Guidance, the Heritage Council acknowledges the co-operation and support of many agencies and individuals, in particular the National Parks and Wildlife Service.

RÉAMHFHOCAL

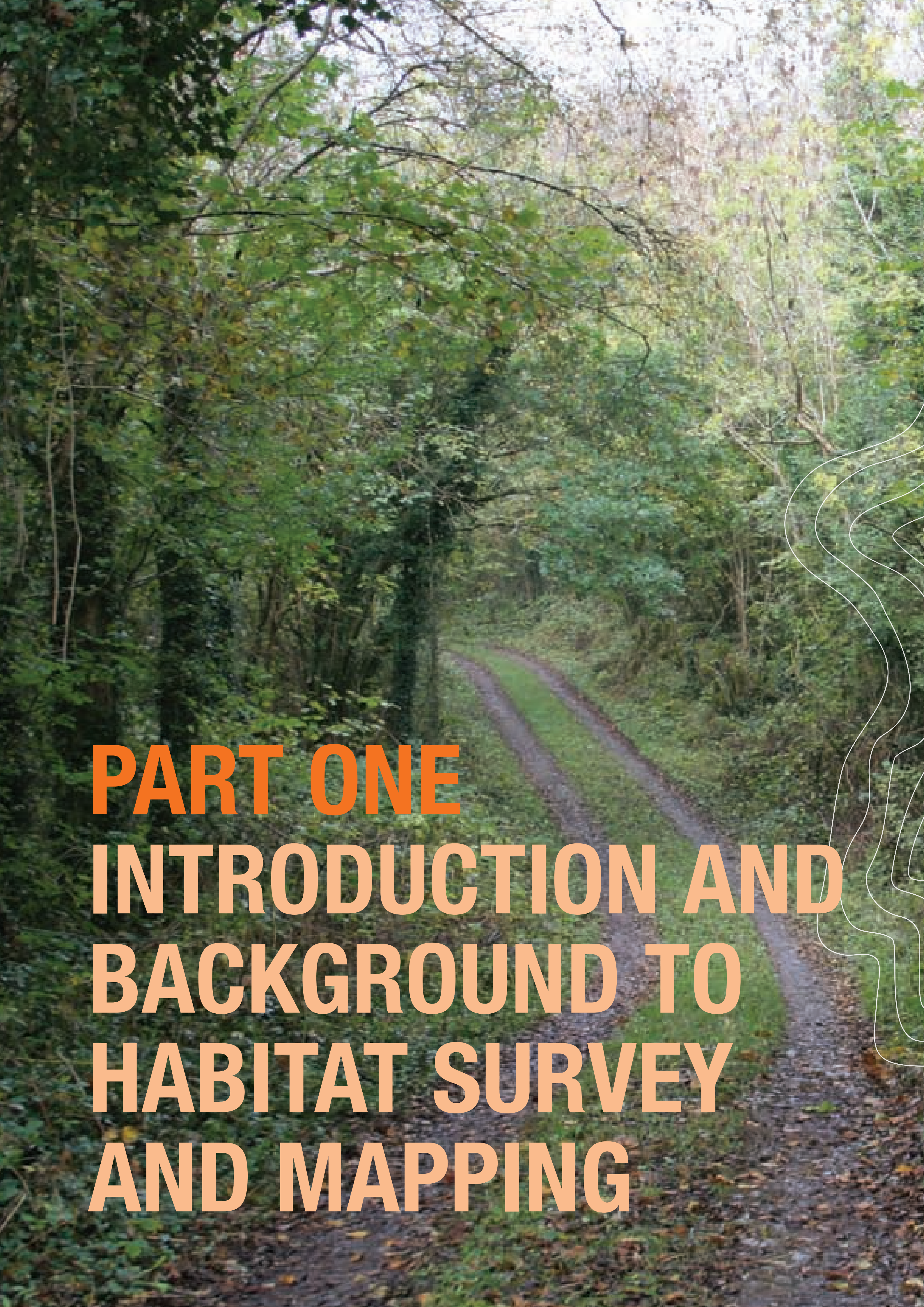
Soláthraíonn an foilseachán seo treoir don chleachtas is fearr do shuirbhéireacht agus mhapáil gnáthóg in Éirinn, agus tá sé dírithe go príomha ar an éiceolaí gairmiúil a bheadh, b'fhéidir, ag bainistiú nó ag dul i mbun a leithéid d'obair, chomh maith leo sin a dhéanfadh coimisiúnú uirthi.

Tá súil ag an gComhairle Oidhreachta go gcuirfidh feidhmiú na treorach sa doiciméad den chleachtas is fearr seo go mór le mapaí ardchaighdeáin gnáthóg a bhaint amach in Éirinn. Is féidir agus is cóir mapaí den chineál seo a úsáid le heolasú a dhéanamh ar chinntí fadtéarmacha nó ar phleanáil chun cinn agus le tacaíocht a thabhairt do pholasaithe agus do thionscnaimh náisiúnta. Bíonn tionchair shuntasacha ag cinntí den chineál sin ar ár bpobail, ár dtírdhreach, ár gcomhshaol, agus ar cháilíocht ár mbeatha. Bíonn tionchar ag roghanna ar bhonn mapaí den chineál sin – nó, níos suntasaí fós, ina n-éagmais – ar na seirbhísí éiceachórais a sholáthraíonn ár n-oidhreacht nádúrtha dúinn ar bhonn laethúil. Níl aithint agus tuiscint ar an méid sin ach ina thús le blianta beaga anuas. Creideann an Chomhairle Oidhreachta go mbeidh an foilseachán seo ina chéim thábhachtach chun cinn i dtáirgeadh faisnéise ardchaighdeáin gur féidir a chomhtháthú go hiomlán sa phróiseas déanta cinnidh, le leas ár bpobal agus ár n-oidhreachta.

Trí fhoilsiú na Treorach seo, admhaíonn an Chomhairle Oidhreachta comhoibriú agus tacaíocht ó iliomad gníomhaireachtaí agus daoine, go háirithe an tSeirbhís um Páirceanna Náisiúnta agus Fiadhúlra.

Conor Newman
Chairman

Michael Starrett
Chief Executive



PART ONE
INTRODUCTION AND BACKGROUND TO HABITAT SURVEY AND MAPPING

1 INTRODUCTION

1.1 Scope

The objective of this Guidance document is to present current best practice guidance for survey and mapping of habitats in the Republic of Ireland. It is aimed at those who conduct or commission habitat surveys, and to inform those who use the final product. This Guidance also aims to standardise and improve habitat survey and mapping methods in order to achieve compatibility among surveys and surveyors, and to ensure quality and consistency of the maps and data produced. Furthermore, it attempts to address the differing and often conflicting requirements of survey objectives and scale and the diverse needs of organisations involved in the collection of habitat data.

This Guidance is intended for use in survey and mapping of terrestrial, freshwater and coastal habitats. Surveys of marine and sublittoral habitats are beyond the scope of this Guidance.

The Heritage Council's *A Guide to Habitats in Ireland* (Fossitt, 2000) is the standard habitat classification system used in Ireland (hereafter referred to as the *Guide to Habitats*). As it is likely to be revised in the coming years, this Guidance is intended to be flexible enough to accommodate any future changes to that publication. While feedback on the current habitat classification scheme was received during preparation of this Guidance, revisions to the scheme are outside the scope of this study. Some guidance is provided on the use of the EU Habitats Directive's Annex I list of habitats of European conservation importance (European Commission, 2007) and other specialist habitat classification systems.

The issue of survey scale is central to habitat survey and mapping. At present, habitat surveys range in scale from those being commissioned by local authorities for strategic planning over relatively large areas to site-based surveys at a smaller scale, such as those conducted for site-based studies, management plans, or Ecological Impact Assessments (EcIA). Somewhat different approaches are required for different scales, and this document endeavours to provide guidance that is flexible enough to accommodate these differences.

The objectives of different habitat survey projects can also differ significantly; these in turn influence the type and manner of data collection. This Guidance endeavours to be flexible enough to accommodate the varying objectives of different studies, while ensuring that the resultant habitat survey data are mutually compatible; this is consistent with the need to store archivally stable data on biodiversity in Ireland. Research projects in particular usually require the use of additional techniques for studying plant communities, faunal assemblages and ecosystem properties that are beyond the scope of this Guidance. Where appropriate, some guidance on further sources of information to design and conduct such studies is provided.

Given the potential for variation in habitat survey and mapping projects, study objectives and methods should be articulated clearly. In particular, any changes to the methodology recommended in this Guidance should be noted to allow for data to be viewed in the correct context and to permit follow-on surveys to use the same methodology, where appropriate.

Recent advances in computer hardware and software are such that computer-based data storage, manipulation and presentation are becoming the norm. This Guidance therefore provides advice on the use of Geographic Information Systems (GIS) for the generation of consistent, high-quality habitat mapping. Advances in information technology have made GIS widely available, and the use of GIS to prepare habitat maps and to compile habitat survey data is strongly encouraged. The advantages of GIS are not limited to cartography and include the ability to link geospatial information with underlying data. However, this Guidance is not intended as a comprehensive GIS manual.

Box 1. What is a habitat survey?

A habitat survey is a method of gathering information about the ecology of a site. The fundamental piece of information collected is the habitat type to which a particular area can be assigned. Habitat types are determined by reference to a system of habitat classification, which must be clearly identified. The location and extent of different habitat types that are present in a site are mapped to provide a clear spatial record. Additional information on habitats may also be collected, such as dominant species or conservation status, depending on the objectives of the particular habitat survey. The results of a habitat survey provide basic ecological information that can be used for biodiversity conservation, planning and/or management, including targeting of more detailed botanical or zoological investigations.

To use this Guidance, surveyors must have sufficient botanical and ecological expertise to be able to identify habitat types following the *Guide to Habitats* and the *Interpretation Manual* (European Commission, 2007) of habitats listed in Annex I of the Habitats Directive. Similarly, those undertaking GIS elements of survey and mapping must have the required degree of competence in digital data capture, management and presentation. This Guidance is not a substitute for skill and experience.

1.2 Need for Best Practice Guidance

The *Guide to Habitats* and the draft *Habitat Survey Guidelines* (Natura, 2002, 2005) represent the first attempts to present a unified methodology for habitat survey and classification in Ireland. Their publication coincided with a substantial increase in the volume of habitat data being collected for a variety of purposes. At the time of writing, however, information on the area, distribution and conservation value of different habitat types in Ireland is piecemeal. Survey coverage is patchy, with only a few areas comprehensively surveyed (such as those included in county-based surveys sponsored by local authorities and the Heritage Council). Habitat surveys of particular sites are biased towards designated sites of high conservation value or areas that have been or may be subject to development and habitat change. More detailed information is available for some natural habitat types (such as National Parks and Wildlife Service [NPWS] sponsored surveys of grasslands, woodlands and other habitats), but data are usually in the form of isolated sites scattered across the country.

Red valerian, a common feature of stone walls and other stonework (BL1) [Atkins]

1 INTRODUCTION

The uses to which collected habitat data are put are equally diverse. These can include:

- Strategic land-use planning
- Identification of natural areas and ecological networks for conservation
- Conservation management and monitoring
- Ecological Impact Assessment (EcIA), Environmental Impact Assessment (EIA) and Appropriate Assessment (AA)
- Informing habitat creation or restoration
- Providing a framework or baseline for more detailed ecological research
- Public awareness and education

The considerable variation in methodology and quality of habitat surveys leads to significant difficulties in collating and comparing habitat survey datasets among different projects, geographic areas and habitat types. Some examples of current problems include, but are by no means limited to:

- Discrepancies among surveyors in their interpretation of classification systems, such as the *Guide to Habitats* and the EU *Interpretation Manual* (European Commission, 2007)
- Difficulties in determining whether particular habitat patches have been identified remotely or by field survey and the level of detail in the field survey
- Differences in digital map capture methods, data quality control methods and metadata preparation leading to errors and inconsistencies, and thus a lack of confidence in the quality of habitat maps and survey data
- Variation in approaches to evaluation of conservation value and habitat condition, leading to difficulties in comparing areas identified as being of high conservation value in a local context from one habitat survey to another (this issue is beyond the scope of this Guidance)

This Guidance provides best practice guidance for habitat survey that, if followed, will address some of the above problems and facilitate the generation of high-quality, consistent and interoperable habitat mapping data.

1.3 Habitat Survey Methodology

A well-planned and executed habitat survey should be conducted in five main steps, as outlined in Table 1.1. These are discussed in the chapters indicated. Before guidance on habitat survey methodology is detailed, background material on habitat classification, maps and GIS is presented briefly. An overview of this document is shown in Box 2.

Table 1.1: Habitat Survey Methodology — Five Main Steps

Step	Activities	Chapter
1	Planning the scope and execution of the habitat survey in line with survey objectives	4
2	Review of desktop information to assist field survey work	5
3	Field-based habitat survey and mapping, and compilation of additional information dependent on study objectives	6
4	Compilation of the final habitat survey GIS database, other data and project report	7
5	Interpretation of the results of the habitat survey and ecological studies beyond habitat surveying	8

Box 2. Overview of Guidance

This Guidance is divided into four main parts, corresponding with the phases of a well-designed habitat survey. Each part contains one or more chapters.

Part One — Covers the scope of this Guidance and habitat surveying in general. Provides a background to habitat classification. Introduces important concepts in mapping and GIS.

Chapter 1 — Introduces the **scope and rationale** of this Guidance. Outlines the uses to which habitat survey data can be put. Highlights the need for best practice guidance for habitat survey and mapping.

Chapter 2 — Provides important background material on the objectives and history of **habitat classification**. Discusses habitat classification systems used in Ireland, including some British and European systems. Provides guidance on the most appropriate systems to use in different surveys.

Chapter 3 — Presents an overview of **maps and GIS**. Briefly addresses the issue of different coordinate reference systems, followed by an overview of current and historical mapping by Ordnance Survey Ireland (OSi) and other bodies. Introduces the use of remotely sensed imagery (primarily aerial photography). Presents issues relating to spatial data quality. Briefly discusses the structures and uses of GIS, along with data types, software, metadata and Global Navigation Satellite Systems (GNSS).

Part Two — The pre-field survey stage, including planning and desktop review.

Chapter 4 — Covers the **planning and management** of habitat survey projects, including the scope of habitat surveys, the general habitat survey methodology, project staffing and oversight, and practicalities such as file management and division of the survey area.

Chapter 5 — Addresses **desktop review** of existing information. Outlines acquisition and use of base mapping, aerial photography, existing GIS data sources and other habitat information. Discusses guidance for consulting with other organisations and individuals who may hold relevant information.

Part Three — Covers the **field survey** in Chapter 6. Topics include: health and safety of field workers, preparation for field recording, and guidance on the nuts and bolts of field surveying. The latter includes some advice on dealing with habitats that are tough to classify, including mosaics, transitional habitats and urban areas.

Part Four — Concerned with aspects of habitat survey and mapping projects post-field survey.

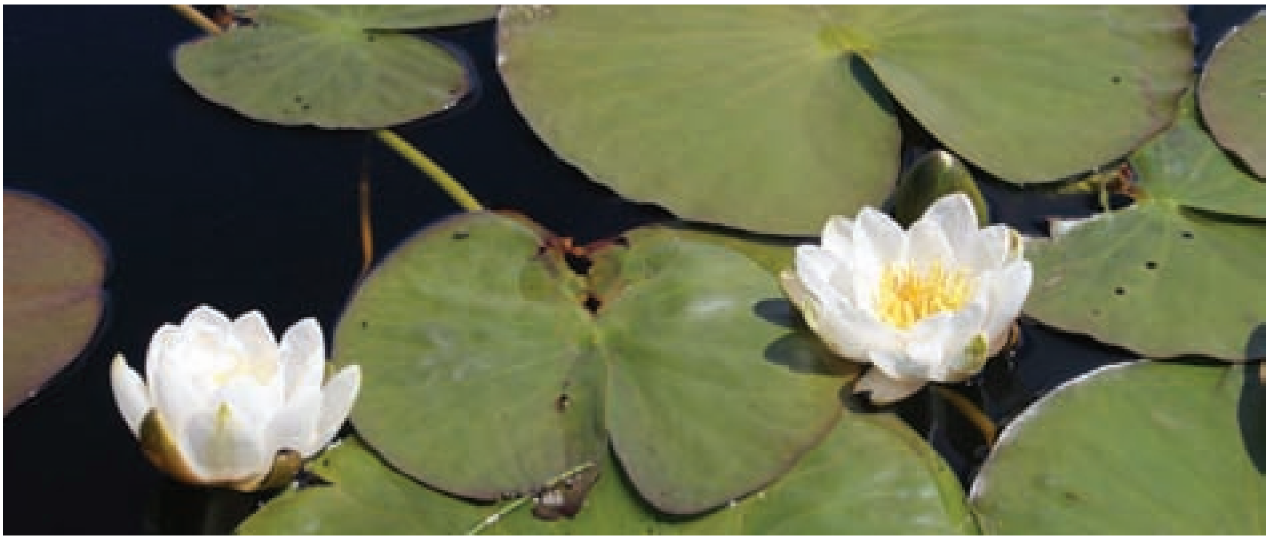
Chapter 7 — Provides best practice guidance on constructing the **GIS database** and generating **habitat maps**. Addresses the structure of habitat databases and digitising habitat maps. Provides guidance on quality assurance and management of habitat survey databases. Discusses final presentation of habitat maps.

Chapter 8 — Addresses the final uses of habitat survey data. Includes information on the production of spatial statistics, evaluation of the conservation importance of habitats, and assessment of habitat condition and threats. (Provision of specific guidance on these is beyond the scope of this document.) Brief guidance on the requirements and methods for detailed vegetation description and quantitative analysis.

2 HABITAT CLASSIFICATION

A system of habitat classification is a necessary prerequisite for habitat survey and mapping. A number of habitat and vegetation classification schemes have been used in Ireland. Some understanding of the various schemes and their origins, uses and limitations is important for those involved in habitat surveys.

A habitat classification scheme is not the same as a vegetation classification scheme, although habitat classifications often rely heavily on vegetation. Vegetation classification is based on the relative abundance of different plant species and sometimes on differences in vegetation structure. Where areas to be mapped support similar plant species or little or no vegetation, vegetation classification is of little use. In contrast, habitat classification schemes use characteristics of the physical and chemical environment and features of human management, in addition to plant species composition and structure, to categorise ecological habitats. Nonetheless, the uses and methods of habitat and vegetation classification are similar in many ways.



White water-lily *Nymphaea alba* commonly found in lakes, ponds and the backwaters of rivers [Atkins]

2.1 Past Approaches to Classification

One of the earliest formal methods of vegetation classification is phytosociology, which has had a strong influence in Ireland and Europe. Originating in continental Europe, phytosociological classification systems are based on the *association*, an ideal plant community to which examples of real-world vegetation are referred. It is defined by a number of character species that are more or less faithful to that association. The association is part of a multi-layer hierarchy analogous to taxonomic hierarchies for organisms. Each association has a formal name that is based on its character species; for example, upland oak woodlands on acid soils in Ireland are referable to the Blechno-Quercetum association. Phytosociology was firmly established as the main school of vegetation analysis in Ireland following the excursion of Braun-Blanquet and Tüxen, two of the founding figures of phytosociology (Braun-Blanquet and Tüxen, 1952).

Much of the basic research on Irish plant communities that informs the currently used habitat classification schemes was conducted using phytosociological concepts and methods. Unfortunately, the phytosociological classification systems used in Ireland have varied according to author and over time. Therefore, when comparing findings from different sources, the associations or higher levels in the classification hierarchy referred to

Dry siliceous heath (HH1) with abundant heather [Atkins]

may not be equivalent. White and Doyle (1982) provide the most comprehensive overview published of Irish vegetation classified according to the phytosociological system. A more recent synthesis of phytosociological classification with reference to Britain (Rodwell, 2000b) is summarised in the *Guide to Habitats*. Although little if any plant ecology research is done at present following traditional phytosociological methods, the system has contributed much to current methods and understanding of habitats in Ireland.

A habitat classification system formerly used in Ireland is the Area of Scientific Interest (ASI) scheme — this was used in the resurvey of ASIs[1] prior to their proposed designation as Natural Heritage Areas (NHAs) (Lockhart *et al.*,1993). Sites were characterised by the abundance and condition of the different habitats they contained according to the scheme. The system divides terrestrial, freshwater and marine habitats into 51 simple types in a non-hierarchical arrangement. The habitat types defined are relatively broad; for example, the categories 'Heath, Fens and Flushes' and 'Dry Broadleaved Semi-natural Woodland' each encompass a diversity of different vegetation communities. This scheme partly served as the framework for the *Guide to Habitats*, in addition to information from phytosociological research, British classification schemes, the Habitats Directive classification and CORINE (Coordination of Information on the Environment) (Fossitt, 2000).

In Britain, the rigorous continental methods of vegetation ecology never found widespread favour. A less formal system of naming habitats and plant communities developed over time and owed much to the early work of Tansley (*e.g.* Tansley, 1949). In the 1970s, the British Nature Conservancy Council (now the Joint Nature Conservation Committee, JNCC) began developing its methods for broad-scale habitat surveying, known as Phase 1 survey. As part of the survey method, a habitat classification system for use during Phase 1 surveys was developed and further refined in the 1980s (JNCC, 2007). The Phase 1 classification system is a habitat classification system, and uses physical, structural and management features to identify habitat types. The system is still used in Britain and was frequently used in Ireland prior to the publication of the *Guide to Habitats*; it continues to be widely used in Northern Ireland.

The breadth of the habitat types and the subjectivity of some of their definitions in the Phase 1 classification meant that this system was unsuitable for some management and research applications. A classification methodology based on objective data analysis was desirable. This led to the production of the British National Vegetation Classification (NVC), the results of which were published in five volumes from 1991-2000 (Rodwell, 1991a, 1991b, 1992, 1995, 2000a), with a user's guide published subsequently (Rodwell,

[1] ASIs were sites of international, national and local importance for conservation of habitats, flora, fauna and geological features identified by An Foras Forbartha in the 1970s and 1980s. Most former ASIs are now NHAs, pNHAs, SACs or SPAs.

2006). The British NVC is based on extensive field survey of vegetation across Britain in a diversity of habitat types. Final NVC vegetation classes were determined by numerical cluster analysis of the vegetation data, which leads to a more objective classification than earlier, more subjective methods. NVC vegetation classes are not arranged in a hierarchy, although they are grouped by broad habitat type (*e.g.* woodland, mire etc.). The NVC has rapidly become the standard vegetation classification used in Britain, and it is sometimes employed in Ireland. Although some comparisons can be usefully made between Irish vegetation and British NVC classes, these must be done with caution as there are environmental, biogeographical, and past and present land-use differences between Britain and Ireland, and none of the data on which the British NVC is based were collected from Ireland.

2.2 Habitats Directive

The EU Habitats Directive aims to protect European biodiversity at the species and habitat levels. The habitats considered to be of most nature conservation importance at a European level are listed on Annex I of the EU Habitats Directive. In this Guidance document, these are referred to as 'Habitats Directive habitat types'. Member States are obliged to protect a proportion of the European resource of each Habitats Directive habitat type by designating sites for nature conservation in order to maintain or restore the favourable conservation status of these habitat types.[2] Habitats Directive habitat types are described in *The Interpretation Manual of European Union Habitats* (European Commission, 2007). They are part of the earlier Palaearctic (European) habitat classification system (Devillers and Devillers-Terschuren, 1993), which was in turn based on the CORINE biotopes system (European Commission, 1991). The latter system is related to, but is not the same as, that used in the CORINE land cover mapping project (discussed in

Turlough (FL6), a priority Annex I habitat [Atkins]

[2] In addition, sites may be designated solely for species listed on Annex II of the Habitats Directive.

Appendix C). The CORINE biotopes system, and hence the Habitats Directive habitat types, use phytosociological classification as the main reference for the lower divisions. They also make use of physical features and integrated ecosystems for the higher and some lower divisions. Ireland has examples of 59 Annex I habitats, of which 16 are priority habitats (those considered to be 'in danger of disappearance' according to Article 1 of the Habitats Directive).[3] It should be noted that 'in danger of disappearance' takes restricted geographical distribution of a habitat into account.

2.3 Current and Future Irish Systems

A *Guide to Habitats in Ireland* (Fossitt, 2000), the main national classification system in current use in the Republic of Ireland, arose from the need to standardise habitat nomenclature and data collection. As noted, this classification system is based on a synthesis of existing research on Irish habitats, including phytosociological research. It is a hierarchical habitat classification system, similar to the British Phase 1 habitat classification. The *Guide to Habitats* draws parallels, where appropriate, between its habitats and phytosociological syntaxa and Habitats Directive habitat types. The *Guide to Habitats* is intended as 'a first-step approach for general habitat recording rather than as a basis for detailed study and evaluation' (Fossitt, 2000).

In parallel with the *Guide to Habitats*, some other habitat classification systems are currently in use in Ireland. These are summarised in Box 3.

NPWS coordinate ecological surveys to gather comprehensive baseline data on the ecology and status of different habitats of nature conservation interest in Ireland. The objectives of these surveys include the gathering of information on the conservation status of habitats, including species composition and vegetation structure. Such information can be used to develop and revise habitat classifications. For example, the National Survey of Native Woodland (NSNW) identified four woodland groups varying according to soil moisture and pH, each of which is further divided into three to eight vegetation types (Perrin *et al*., 2008a, b). The NSNW woodland classification, along with those developed by other projects, has been produced by numerical cluster analysis of plant abundance data collected in a large number of vegetation sampling plots or relevés.[4] This detailed, quantitative information has the potential to be used to develop a new or revised vegetation or habitat classification for Ireland in conjunction with further habitat classification research. Development of a new vegetation classification or a new habitat classification is one of the long-term goals of the NPWS, working with the National Biodiversity Data Centre.[5] The National Vegetation Database project is currently collating vegetation relevé data from a wide variety of published and unpublished sources for this purpose.

Two conclusions are clear from this discussion of the multitude of habitat and vegetation classifications in Ireland and elsewhere in Europe:

1. *The best classification system to be used in a habitat survey depends on the objectives of the survey and the final uses of the data.* In Ireland, baseline habitat survey and mapping should use the system in the *Guide to Habitats* and also the Habitats Directive habitat types. More specialised classification systems may be required, depending on the goals of the survey.

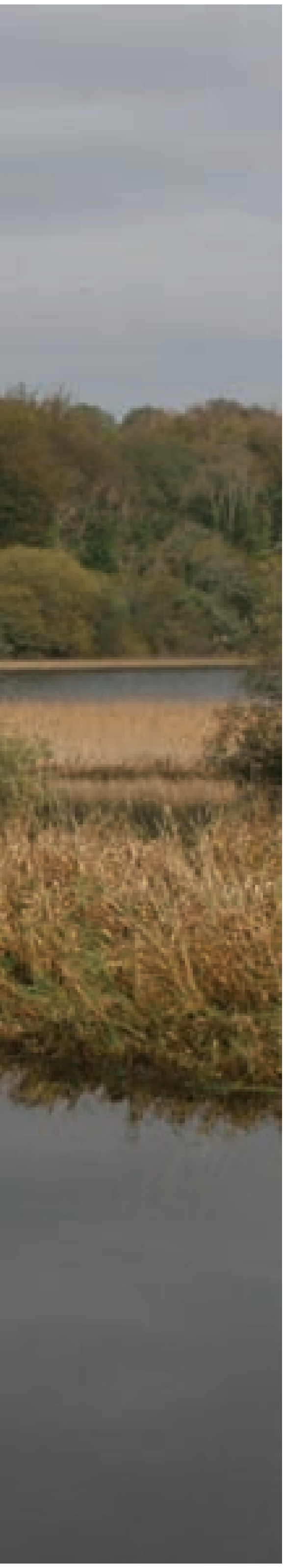
2. *Habitat or vegetation types are not real.* They are simply approximations — artificial labels for the purpose of convenience — and therefore no classification system is perfect. Some areas encountered on the ground will be transitional types, hopelessly intimate mosaics, or just plain strange, and will be difficult or impossible to classify neatly. However, such areas should not be ignored, as they may be of particular ecological interest. In these cases, particular care in describing the habitats is necessary, and more detailed quantitative recording of species abundances may be warranted.

[3] *See www.npws.ie*

[4] *The term **relevé** derives from phytosociology, and strictly speaking refers to the record of vegetation taken from a fixed area. Now, it is more commonly used as a synonym for plot or quadrat.*

[5] *The National Biodiversity Data Centre is an initiative of the Heritage Council. It is funded by the Department of the Environment, Heritage and Local Government and is operated under a service level agreement by Compass Informatics.*

Reed and large sedge swamp (FS1) along wooded lake margin [The Heritage Council]



Box 3. Other habitat classification systems used in Ireland

Although the *Guide to Habitats* is the standard habitat classification scheme currently used in Ireland, other systems are used for more specialist purposes and include:

- Bird-habitat classification system (Crick, 1992): a hierarchical habitat classification and coding system emphasising habitat structure for use in bird surveys
- CORINE Biotopes (European Commission, 1991): an earlier European habitat classification system on which the habitat classification system used in Annex I of the Habitats Directive is based
- EUNIS European Nature Information System habitat classification (http://eunis.eea.europa.eu/): a revision of the earlier Palaearctic habitat classification on which the Habitats Directive scheme is based; use of the EUNIS habitat classification is required for some European-level reporting
- Habitat association databases for invertebrate groups (*e.g.* Speight, 2008; Bond and Gittings, 2008)
- Hedgerow Survey Methodology in Ireland (Murray and Foulkes, 2006): widely used method for surveying and classifying hedgerows
- Marine Nature Conservation Review (MNCR): Marine Biotope Classification for Britain and Ireland (Connor *et al.*, 1997): used in the classification of marine habitats, which are generally outside the scope of this Guidance
- Native Woodland Scheme classification system (J. Cross in Forest Service, 2008): used for planning native woodland restoration and creation
- River Habitat Survey in Britain and Ireland (Environment Agency, 2003): assessment of riverine habitats
- Ad hoc classification systems: botanical and zoological research often involves delineation of habitat types for the purposes of that particular study

3 MAPS & GEOGRAPHIC INFORMATION SYSTEMS (GIS)

3.1 Overview

A Geographical Information System (=) is one that permits the capture, manipulation, storing, checking, analysis, integration and display of spatial data (Burrough and McDonnell, 1998). It is capable of geographically referencing information that originates from a variety of sources and formats. Worboys and Duckham (2004) described GIS as a special type of computer-based information system tailored to store, process and manipulate geospatial data. This Guidance document outlines current best practice in terms of Geographical Information Systems and is not concerned with other aspects of GIScience.[6]

3.2 Introduction to Mapping

3.2.1 Map Projections and Coordinate Reference Systems

In order to create a map, it is necessary to use some sort of mathematical formula to transform spherical geographic coordinates on the Earth's surface so they can be represented in two dimensions. This process results in a map projection that approximates the true shape of the Earth. A map projection is a special configuration used to fit a portion of the globe onto a flat view (Davis, 1996). This process introduces errors into spatial data, the character of which will vary depending on the projection used (Heywood *et al.*, 2006). Each projection has its specific areas of distortion and its own set of advantages and disadvantages. The main areas of distortion are shape, area, distance and direction. A cartographer will attempt to eliminate distortion by choosing the most suitable projection, depending on the map's purpose and the area covered.

After deciding on a suitable map projection, a suitable coordinate reference system must be chosen. A coordinate reference system consists of a set of assigned points on a flat surface, which originate from a set of predefined rules. These points – often referred to as latitude and longitude, or eastings and northings – define the position of the geometry relative to a false origin on the Earth's surface.

Currently, there are two coordinate reference systems in common use in Ireland: the *Irish Grid (IG)* and the *Irish Transverse Mercator (ITM)*. These two coordinate reference systems currently run in parallel with each other. The IG is the older of the two systems, and the Ordnance Survey Ireland (OSi) is in the process of migrating to ITM.

The IG covers both the Republic of Ireland and Northern Ireland. Map positions expressed in this system are based on a coordinate reference frame observed by two primary triangulations during the 1950s and 1960s. These were combined in one adjustment in 1975 to produce geographic positions (latitude and longitude) for the primary stations in the reference frame (OSi, 2009). Positions on maps are expressed in two dimensions as eastings and northings, with a false origin off the south-west coast of Ireland.

ITM is the new coordinate reference system for Ireland. It was implemented jointly by the OSi and the Ordnance Survey Northern Ireland (OSNI) in 2001. OSi datasets and mapping are available in both coordinate reference systems. At the time of writing, IG is the more commonly used of the two coordinate reference systems, although ITM is the more accurate. Therefore, the choice of which to use for a habitat survey project may depend on the final use to which the habitat mapping data will be put and what coordinate reference system(s) is available for baseline mapping and other geographical datasets that may be used. However, OSi have recommended that all data should initially be captured in ITM in order to maximise accuracy and precision; data can subsequently be translated to IG where required.

*[6] Mark (2003) describes GIScience as '**the basic research field that seeks to redefine geographic concepts and their use in the concepts of geographic information systems**'. GIScience incorporates spatially oriented disciplines such as geography, cartography and geodesy, with recent developments in cognitive and information science, while drawing on more specialised research fields such as computer science, statistics and mathematics.*

There are a number of recognised shortcomings of the IG coordinate reference system, which include (OSi, 2008a):

- Not directly GNSS (*e.g.* GPS) compatible – use in combination with GNSS involves a coordinate transformation using complex mathematical formulas, thus introducing positioning error
- Not internationally compatible with European Terrestrial Reference System 1989 (ETRF89)
- Only accurate to greater than 1 metre using GNSS

According to the OSi (2008a), one of the main benefits of mapping based on the ITM coordinate reference system is improved positional accuracy of data. This positional accuracy is achieved through:

- Reduced distortions compared with IG
- Use of a coordinate reference system that is directly compatible with GNSS
- Use of new OSi active control network for data capture
- The collection and re-alignment of baseline OSi map data to these standards

For guidance on how to read a grid reference, see the National Biodiversity Data Centre (2010) for more information at www.biodiversityireland.ie

3.2.2 Irish Maps

OSi maps are a basic requirement for any mapping exercise. For habitat surveys, the most useful maps are those that depict field boundaries, roads and watercourses. Maps which fall into this category include:

- Historical 6-inch (raster) (1:10,560)
- Historical 25-inch (raster) (1:2500)
- Current vector maps (1:1000, 1:2500, 1:5000)

Monbretia dominated coastal roadside [The Heritage Council]

The 6-inch and 25-inch maps are out-of-date, but are of great value for determining land-use history, such as history of woodland cover. Both sets of maps are available in digital (raster) and hard copy formats. The 1st edition 6-inch maps were produced between 1829 and 1842 by the Ordnance Survey. This was the first-ever large-scale survey of an entire country and was undertaken on a county-by-county basis at a scale of 6-inches to one mile.

A second survey was commissioned between 1887 and 1913 at a scale of 25-inches to one mile. Both the 25-inch and the 6-inch maps are available in both black-and-white and colour format. Although many landscape and specific habitat features have changed somewhat since these maps were produced, they can provide information on past land uses, watercourse channels, woodlands, quarries, archaeological features, townland names etc.

3 MAPS & GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Revisions to both the 6-inch and 25-inch maps were undertaken from 1845 until the early 1980s. Demand resulted in some counties being revised more often than others, with surveying carried out in different years.

If using 6-inch or 25-inch mapping, the appropriate version of the map should be checked with the OSi. Six-inch mapping has been extensively used as baseline mapping for previous ecological work, and is still used for some applications.

Caution should be exercised when using historic mapping or datasets derived from historic mapping, as there are legacy distortion issues with the maps and therefore derived datasets. Distortion arises from the map projection used to capture the original data. The Cassini projection was used to construct Irish 6-inch and 25-inch maps. The Cassini projection uses a scale along a central north-south meridian. Scale along the central meridian and at right angles to it is accurate, but everywhere else, scale – and therefore mapped objects — are distorted in a north-to-south direction. The amount of distortion on the map increases with distance from the central meridian. In Ireland, the Cassini projection was applied on a county-by-county basis for 6-inch and 25-inch mapping, with the central meridian passing through a point near the centre of the county. Therefore, distortion is most evident near county borders, and also in rivers, lakes and streams. Distortion and error inherent in the dataset are amplified during translation and re-projection using IG and ITM. It should be noted that these distortions are present in datasets derived from 6-inch and 25-inch mapping, including designated area boundaries datasets. Due to the spatial errors inherent in the 6-inch and 25-inch maps, their use as baseline mapping for habitat survey and mapping is not recommended.

Other historic mapping — such as estate maps and Bogs Commissioners maps, maps which accompany local vegetation surveys, such as the Dublin Mountains (Pethybridge and Praeger, 1905) and Clare Island (Praeger, 1911), and even landscape paintings and prints — can yield valuable information on habitat and land-use history. White (2006) provides an excellent overview of the history and sources of vegetation mapping in Ireland.

Current large-scale vector mapping data is captured by the OSi at three different scales: 1:1000, 1:2500 and 1:5000. There is full coverage in Ireland of vector mapping, but the scale available for a given area and the frequency of planned revisions varies (Table 3.1). Vector mapping is available digitally in tiles that cover a fixed area, depending on scale. These datasets are also available in raster format.

Table 3.1: Description of OSi Large-scale Vector Mapping

Scale	Planned Revision	Coverage	Specification
1:1000 (urban)	Annually	1810 tiles covering urban areas	Each tile measures 800 m x 600 m
1:2500 (suburban & peri-urban)	Suburban maps to be revised annually	4700 tiles covering selected suburban and peri-urban areas of Ireland	Each tile measures 2000 m x 1500 m
	Peri-urban maps to be revised every 3 years		
1:5000 (rural)	Every 5 years	7000 tiles covering rural areas of Ireland	Each tile measures 4000 m x 3000 m

Discovery Series mapping is derived by the OSi from 1:10,000 digital databases and 1:40,000 aerial photography with field verification. It is available at a scale of 1:50,000 and highlights topographical features (using contour lines), road networks, water bodies, archaeological features, and wooded and urban areas. It should be noted that the identification of broadleaved, coniferous and mixed woodland on Discovery Series mapping is unreliable. There are also discrepancies on how some permanent and seasonal water bodies, including turloughs, are mapped. Discovery Series maps are widely available as folded paper copies and are also available in digital format as 40 km x 30 km tiles. Discovery Series mapping is available for the whole country in both raster and vector formats. A limited number of 1:25,000 Special Interest Maps (Leisure Series) derived from the Discovery Series is also available as printed maps for certain areas, such as Killarney National Park. Some are also available on weatherproof paper.

Most GIS applications are capable of working with both raster and vector mapping. A description of the merits of vector versus raster mapping is presented in Box 4.

Box 4. Raster and Vector Mapping

The fundamental difference between raster and vector mapping is the way in which the file is constructed. A raster map is a digital image such as an aerial photograph, imagery from satellites, digital pictures, or even scanned maps which are georeferenced. In a raster representation, space is divided into an array of rectangular (usually square) cells. All geographic variation is then expressed by assigning properties or attributes to these cells (Longley *et al.*, 2005). This makes raster data particularly suitable for certain types of spatial operation, *e.g.* overlays or area calculations. A common use of raster data in a GIS is as a background display for other feature layers. Since each point must be represented on the map with a pixel and the colour, such maps can take up a lot of memory. Characteristics of raster data in GIS include:

- Simple data structure
- Simple yet effective representation of two-dimensional space
- Very good at representing continuous space
- Can use data captured from satellite imagery
- Very good in mathematical models that use different data from different databases in various combinations

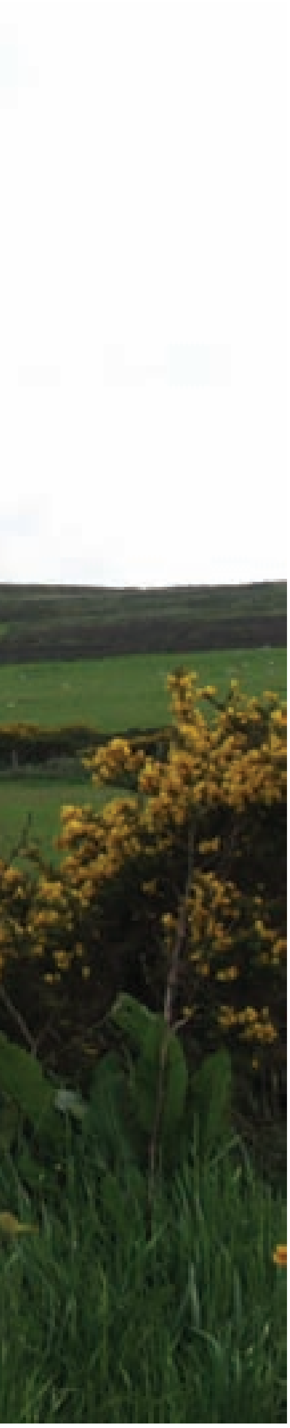
A vector map is an abstraction of the real world where positional data are represented in the form of coordinates. A vector map is the most common representation of a map and consists of points, polylines and polygons. A point, as the name suggests, is a dimensionless point in geometric space defined by an x and y coordinate reference. A polygon is a representation of 2D space and represents an area feature. A polyline is represented by sets of x and y coordinate pairs that define a connected path between points through space, but one which has no true width unless specified in terms of an attached attribute (Burrough and McDonnell, 1998). Each of these geometries is linked to a row in a database that describes their attributes. Displaying vector-based data is resolution independent, and data therefore appear at the maximum resolution of the output device, such as a printer or monitor. The true resolution of vector data is very much dependent on the data capture method. Characteristics of vector data in GIS include:

- Compact data structure
- Very efficient in data storage and graphical display
- Excellent at the large scale and capable of taking advantage of very high-quality graphical display hardware
- Excellent for network analysis of lines
- Easy conversion from polylines to polygons with the correct software

PART ONE INTRODUCTION AND BACKGROUND TO HABITAT SURVEY AND MAPPING

3 MAPS & GEOGRAPHIC INFORMATION SYSTEMS (GIS)

The Sugarloaf Mountain, Co. Wicklow [Atkins]



3.2.3 Remotely Sensed Images

Aerial photography and satellite imagery are the most important sources of raster information to assist in habitat surveying and mapping over large areas. Both provide a visual overview of the survey area at a specific point in time, and can be used for preliminary identification of habitats and in targeting areas of potential ecological interest. The use and interpretation of satellite imagery is a highly specialised field. A number of habitat mapping projects have previously used satellite imagery for habitat mapping (*e.g.* Parr *et al.*, 2005). Significant technical expertise is required for satellite imagery interpretation for habitat mapping; a review of remote sensing using satellite imagery is currently under way by the Environmental Protection Agency (EPA) and therefore is not considered further here.

Aerial photography is the capturing of images from a position above the Earth's surface. Orthophotographs are aerial photographs which have been rectified to remove distortions in order to produce a scale-accurate image (Curran, 1989). The main organisation responsible for capturing and disseminating aerial photography in Ireland is the OSi, although private companies also capture aerial photography and can provide other specialist remote sensing services.

OSi provides digitally scanned and ortho-rectified raster colour and black-and-white photography in both low and high resolution. Digital orthophotography is supplied in TIFF format in 2 km x 2 km tiles and is available georeferenced to IG or ITM. Low resolution OSi orthophotography is flown at 40,000 feet and has a 1 metre per pixel resolution (OSi, 2008b). At the time of writing, the latest rectified images were flown in 2004-2006, and there is full coverage of Ireland available, with a few minor exceptions. High resolution OSi orthophotography with a 25 cm per pixel resolution is available for selected cities and towns (OSi, 2008c).

When using orthophotography, surveyors should be aware of the limitations of the image. Important details to note are:

- The image resolution
- The quality of the image
- The age of the image and, if possible, the month it was taken
- The scale of the image (low flown or high flown)
- How the image was taken (vertically or obliquely)
- The terrain

Image resolution determines the scale to which an image can be enlarged and still show the features clearly. Resolution is determined by the type of camera used, the emulsion grain of the photograph, and the altitude at which the image was captured. Quality of an image is dependent on weather conditions and camera quality. A high-specification camera will yield high-quality images. Cloud cover and poor weather conditions can distort the quality of an image.

3.3 GIS Dataset Structure

A GIS vector-based dataset constructed for a habitat survey is made up of a series of features, each of which represents the location and extent of a habitat patch, *e.g.* a grassland field, a woodland, a watercourse or a hedgerow. The data associated with each feature are known as attributes, and this information is stored in an attribute table. Attribute data are those properties of a spatial entity that need to be handled in the GIS, but which are not themselves spatial (Burrough and McDonnell, 1998). Table 3.2 is a very simple example of an attribute table. Each row in the attribute table is a record, and each column in the table is a field of attributes. Attributes may be expressed in a GIS by a number of data types, including decimals, integers, ordinal data, nominal data, Boolean operators etc.

3 MAPS & GEOGRAPHIC INFORMATION SYSTEMS (GIS)

A group of tables with some shared attributes can also be organised into a relational database. Many GIS systems use a georelational database model to maintain the connection between spatial features and their corresponding non-spatial descriptive data through a unique feature identifier for each geographic feature in the spatial data set. Other GIS users utilise the object relational database model where objects are stored directly in the database linked by their interaction with another object in the database. This Guidance only deals with the georelational database structure.

Table 3.2: Example of an Attribute Table

Object ID Code	Survey Date Code	Irish Habitat Name	Habitat Directive	Habitats	Notes
01	15/7/09	GS4	Wet grassland	6410 by	Lightly grazed cattle; some poaching
02	15/7/09	WN6	Wet willow-invading alder-ash woodland	.	Sycamore
03	16/7/09	FS1	Reed and large sedge swamps	.	On former fen degraded by drainage

Using GIS, it is possible to query an attribute table to produce results that can be mapped spatially or summarised in a table or figure. Data layers can be manipulated by performing mathematical or logical operations. Layers can also be combined to show areas with specific attribute combinations. Spatial queries provide a means of examining the attributes of locations, and the results can be mapped spatially by creating a thematic map. A thematic map is a map which is produced to highlight a particular set of information about a geographic area using colour or hatching. For example, a thematic map could be made that shows all the habitat types in an area differentiated by colour.

Features in a GIS are stored as a series of layers comprising points, polylines or polygons. Each dataset will contain multiple layers for a common geographic area. Each layer can be managed as an information set that is independent of others. When layers are spatially referenced, they overlay one another and can be combined in a common map display to give the appearance of seamless mapping. Assuming these maps are georeferenced according to a common coordinate reference system, information displayed on the different layers can be compared and analysed in combination.[7] GIS analysis operations can therefore integrate information between data layers to derive and reveal spatial relationships.

3.4 Metadata

Metadata, or *'data about data'*, provide documentation of spatial data, describing content, quality, condition, and other characteristics of a dataset. Well-constructed metadata makes information more useful to all types of users by making it easier to find, interpret and use. Metadata gives data credibility, and in many situations, data may be impossible to interpret or use without associated metadata. Geospatial metadata are used to document digital spatial information such as GIS files, geospatial databases, and georeferenced imagery. Geospatial metadata includes standardised elements of geographic information in the metadata structure to facilitate interoperability of digital spatial datasets, such as coordinate reference system and spatial extent. Geospatial metadata are therefore a vital component of any GIS. They can be stored in any file format, including text, XML, or as

[7] Overlaying layers which originate from different sources from analysis and comparison can create issues. Often layers are captured with varying degrees of accuracy and precision and it is important to check the metadata of the layer prior to using it for analysis and comparison.

a database record. Access to metadata can also be controlled so that different levels of access to the metadata — *i.e.* viewing, publishing and editing — can be restricted by the data owners.

The importance of well-constructed metadata has only recently been widely recognised in Ireland. Therefore many datasets that are available at present may be lacking in comprehensive metadata. Following the implementation of the INSPIRE (Infrastructure for Spatial Information in the European Community) Directive (EC 2007/03/14), Member States are required to standardise the handling of geographic information. The INSPIRE Directive sets out a common framework for annotating and sharing geographic data between Member States. This includes the standardisation of metadata. According to Article 5, '*Member States shall ensure that metadata are created for the spatial data sets and services corresponding to the themes listed in Annexes I, II, and III, and that those metadata are kept up to date*'. Habitat survey data are directly related to the Habitats and Biotopes (III.18) theme in INSPIRE.

Spring gentian noted on an upland site in western Ireland [Atkins]

When fully implemented, the INSPIRE Directive should enable data from one Member State to be seamlessly combined with data from all other European States. This is particularly important for cross-border activities relating to the environment. It will also allow data to be discovered and used easily by the wider community within a State. As the focus of the INSPIRE Directive is to enable interoperability of geospatial data across a wide range of domains, in practice it may be necessary to include additional elements beyond those in the INSPIRE metadata schema.

At the time of writing, a pilot online Irish Spatial Data Exchange (ISDE) discovery service and online editor is being developed (Marine Institute, 2010). This will facilitate the creation of INSPIRE-compliant metadata. When using the exchange, it is also possible to search metadata catalogues operated by a number of organisations including, but not limited to, the Marine Institute, GSI, the Department of Communications, Energy and Natural Resources, the Department of the Environment, Heritage and Local Government, and the EPA.

Two other metadata standards are ISO 19115 and Dublin Core. ISO 19115 specifies the information required about the identification, extent, quality, spatial and temporal extent, location and distribution of spatial data required for compliance with International Organisation for Standardisation (ISO) accreditation. INSPIRE is a derivative of ISO 19115 and is based on the same standards. However, the INSPIRE Directive should be used, as both ISO 19115 and Dublin Core do not take into account the spatial nature of the data. Technical guidelines for implementing metadata compliant with both INSPIRE and ISO 19115 are available (DTM and ECJRC, 2009).

The Dublin Core Metadata Element Set is a set of 15 broad descriptors to be applied to any information resource: contributor, coverage, creator, date, description, format, identifier, language, publisher, relation, rights, source, subject, title and type. The broad, core elements are supplemented by additional metadata elements and technical specifications. Dublin Core metadata standards are developed and maintained by the Dublin Core Metadata Initiative (2010).

Habitat survey and mapping projects should ensure that sufficient information is gathered to allow metadata conformant with one or more of these standards to be generated. Statutory bodies are obliged to ensure that metadata for spatial datasets which fall under the terms of one of the INSPIRE Annexed Themes are INSPIRE-compliant. The online INSPIRE editor tool www.inspire-geoportal.eu/InspireEditor/ can assist in the production of INSPIRE-compliant metadata. Further guidance on creating metadata is provided in Section 7.5.2.

3.5 Data Quality

3.5.1 Accuracy

The inherent complexity and detail of the natural world makes it virtually impossible to capture every single facet at every possible scale in a digital representation. It is important for the user of GIS data to understand the differences between the contents of the dataset and the real ecological features that the data represent. Accuracy is the closeness of the results of observations to their true values or, as defined by Heuvelink (1998 in Longley, 2005), the difference between reality and our representation of reality.

There are two types of accuracy:

- Thematic Accuracy
- Positional Accuracy (Relative and Absolute)

Thematic accuracy is concerned with the closeness of attribute values to their true value. Identifying habitat type and other characteristics of habitats can be problematic in some circumstances. Other sources of thematic error include incorrect recording in the field or errors in transcription. Many of the recommendations contained in this Guidance are concerned with minimising thematic error. Minimising and reporting error from existing datasets is discussed in Chapter 5, guidance for reducing error in field data collection are provided in Section 7.3.2, and recommendations for minimising and reporting error during the final project stages, including guidance on quality assurance, are detailed in Section 7.4.

Positional accuracy refers to the true accuracy of the data or how close features are to their true positions. Conventionally, maps are accurate to roughly one line width or 0.5 mm (Longley, 2005), but this will vary with changes in scale. As a useful rule of thumb, this level of conventional accuracy can be extrapolated to distances on the ground at different map scales (Table 3.3).

Table 3.3: Estimates of Positional Accuracy in Distance on the Ground at Different Map Scales (after Longley, 2005)

Map Scale	Positional Accuracy
1:2500	1.25 m
1:5000	2.5 m
1:10,000	5 m

It is particularly important to understand the effect of errors in positional accuracy on the quality of analyses made with GIS (Burrough and McDonnell, 1998). Sources of error in positional accuracy can originate from:

- Errors in baseline data sources, *e.g.* orthophotography, satellite imagery and baseline mapping
- Digitising
- Geodetic control and GNSS
- The use of the incorrect coordinate reference system

The ability to show features on a map is determined by its scale. If using OSi vector mapping as a template for habitat mapping, see Section 7.1.2. Errors in positional accuracy in the original capturing method of the data should be taken into account. According to the OSi (pers. comm.): *'In urban, suburban and peri-urban mapping (1:1000 and 1:2500), the results of testing 5,196 points of hard detail are that 89.9% of the points in the mapping are within 1 metre of their true ground position, and 98.3% of points are within 2 metres of their true ground position. In rural mapping (1:5000), the results of testing 2,267 points of hard detail are that 96.3% of the points in the mapping are within 2.5 metres of their true ground position and that 100% of points are within 5 metres of their true ground position.'*

Positional accuracy varies with the mode of digitising being undertaken, *i.e.* stream digitising or point digitising. An error in positional accuracy through point digitising occurs due to the digitiser's subjective view of what critical topology must be followed to represent the feature accurately. In other words, the digitiser chooses what points or nodes are critical to draw in order to get an accurate representation of the topological feature. Stream digitising is the process where the digitiser selects criteria for automatic placement of nodes or points defining a feature. For example, in stream digitising, the digitiser may place a node every 1 metre or every 30 seconds when tracing underlying features on an orthophotograph. With this technique, errors can occur due to the high density of nodes or points that are captured, and loops, spikes and overlaps can result.

Coordinate reference systems have their own inherent errors in positional accuracy; positional accuracy of IG and ITM reference systems are discussed in Section 3.2.1. In addition, transforming coordinates from one coordinate reference system to another can introduce additional errors.

Accuracy and GNSS are discussed in Section 3.6.

3.5.2 Precision

Precision in GIS can be described by the number of digits used to report a measurement (Longley, 2005). Longley (2005) uses the example of a GPS receiver measuring an elevation to four decimal places, but if the receiver is in reality only accurate to the nearest 0.1 metre, three of those digits are meaningless. Thus, recording elevation to four decimal places produces a false impression of the precision of the measurement.

Uncertainty in habitat mapping arises from a number of sources; habitats frequently exist in intimate mosaics and with gradual rather than abrupt transitions between habitat types. This, in combination with the dynamic nature of many habitats, makes classification of habitats difficult. Consequently, modelling of habitats using discrete, mutually exclusive classes is problematic and is suggestive of a level of precision inappropriate to the nature of the features being mapped. The adoption of fuzzy sets in spatial data modelling, drawing upon methods more traditionally associated with image classification, is being used increasingly in habitat and vegetation mapping.

Exposed calcareous rock (ER2) in the Burren, Co. Clare [Atkins]

Using 'soft' classification techniques, based around the concept of fuzzy sets, each polygon can belong to more than one habitat class, with the degree of 'belongingness' or membership being based on the data collected. In this way, it is possible to query the spatial data for areas which conform to user-defined degrees of membership of selected habitat classes. The data model facilitates the natural continuum of habitats and vegetation, and surveyors are no longer restricted to assigning polygons to a class. The level of precision required — or indeed possible — for particular projects varies greatly. Achieving high precision in spatial measurements is expensive. In addition, it is often not possible to map habitats to a high degree of precision. Boundaries between habitats are often characterised by ecotones, such that it is difficult or impossible to define clearly where one habitat begins and another ends. Therefore, care should be taken to avoid false impressions of high precision when reporting measurements, such as habitat area or length.

The simple rules below will help ensure that those receiving measurements are not misled by their false high precision (Longley, 2005):
- The number of digits used to report a measurement should reflect the measurement's accuracy
- Excess digits should be removed by rounding
- If a number is known to be exactly an integer or whole number, it should be shown with no decimal point

3.5.3 Quality
Quality can be defined as the suitability of a specific dataset for a specified use. Quality is an important factor in any GIS dataset and should be recorded meticulously in the metadata of a dataset. Quality can be assessed under five headings, the first two of which are discussed in detail above:
- Thematic accuracy
- Positional accuracy
- Completeness
- Topological error
- History of the dataset

Completeness refers to the lack of errors and omissions in a database and describes areas that are or are not complete in a dataset. It is assessed according to the project and database specifications.

Topological error arises due to spatial data inconsistencies such as gaps in polylines, duplicate polygons or polylines, slivers and gaps between polygons. Topological errors will have an adverse effect on the interpretability of a dataset.

History of the dataset is concerned with historical and creation aspects of the data. These include but are not limited to issues such as sources of the data, when it was created, how often it was updated and data capture methodology.

3.5.4 Error Propagation
One of the most powerful capabilities of GIS is that it allows new attributes to be derived from attributes already held in the GIS database. No map stored in a GIS is truly error free. Error propagation occurs when one error in the GIS database leads to another error. Users should be aware that errors propagate through their analyses. Providing that a user knows the errors inherent in the base source, it is possible to estimate error propagation caused as a result of data manipulation and analysis.

Further information on quality assurance can be found in Section 7.4.

An example of dry calcareous and neutral grassland (GS1) created on a former landfill, Co. Dublin [Atkins]

3.6 Global Navigation Satellite Systems (GNSS) and Field Computers

Global Navigation Satellite Systems (GNSS) provide field surveyors with the ability to locate their position according to a coordinate reference system, such as IG or ITM, on the ground to within a few metres or less. GNSS use satellite transmissions to a small electronic receiver, such as a handheld device, to determine position. The receiver uses precise time and satellite position data of at least four visible satellites to calculate position coordinates by analysing the time that it takes a signal to travel from the satellite to the receiver. At the time of writing, the most widely used GNSS in Ireland is GPS. The EU is in the process of developing its own GNSS, called Galileo, which is due to become operational in 2013.

Handheld GNSS units, if used properly, can greatly enhance the accuracy of habitat mapping in the field, particularly for locating boundaries between habitat types and point features. Handheld GNSS units are available from a number of manufacturers, such as Garmin, Magellan and Trimble, and come with a wide variety of displays and additional features. Basic units are relatively inexpensive, but their capabilities are usually limited to recording of waypoints and points.

In habitat mapping, GNSS provides two main advantages to field surveyors: an aid to navigation, particularly useful in areas with few landmarks that appear on aerial photos or maps; and the ability to record locations of features of ecological interest. At the most basic level, a handheld GNSS unit provides the user with his/her location according to a coordinate reference system, such as ITM. Basic handheld GNSS units have little or no background mapping. Background mapping is available in more advanced units, although there may be little choice or flexibility in the mapping available for some models.

Individual locations can be written down or saved electronically on the GNSS unit as a survey point. Also, the distance and compass bearing to previously marked waypoints can also be read on the unit. In addition to points, routes walked, such as along a boundary between habitat types, can also be saved as linear features. However, mapping habitat boundaries in this fashion can be time-consuming. Back in the office, waypoints stored in the GNSS unit can be downloaded directly onto a computer for inclusion in the habitat survey GIS dataset.

Densely planted conifer plantation (WD4), which can interfere with GPS signal [Atkins]

Accuracy of positions given by a basic GNSS unit usually ranges from 5-15 metres, but is sometimes worse, depending on a number of factors, including:

- Satellite clock and position errors
- Atmospheric delay of the transmitted satellite signals
- Atmospheric and ionospheric error
- Receiver noise and receiver clock errors
- Multipath (signal reflection)
- Satellite position in sky relative to receiver

In the field, the latter error source is strongly influenced by terrain and vegetation structure. Where terrain or vegetation reduces the amount of signal the unit can receive from the satellites, positional accuracy can be significantly lower; in woodlands, positional accuracy of better than 10 metres is often not possible. Atmospheric and ionospheric error sources in particular, such as solar activity, can be significant; however, more advanced GNSS can minimise the remainder of the error sources. Nearly all GNSS units provide an estimate of positional accuracy, which should always be recorded and reported. More advanced GNSS units provide greater accuracy through software-based post-processing of waypoint information. In Ireland, the OSi has established a series of fixed geodetic control points situated throughout the country at known locations. The positions of these control points are known with high precision. Coordinates recorded with a GNSS unit can be examined using software which compares the points with reference to the geodetic control point network. In real-time kinematic mapping, position is corrected through radio modem communication with control points, eliminating the requirement for post-processing. Potentially, other GNSS units can provide greater accuracy through communication with GNSS augmentation satellite systems. At the time of writing, the European augmentation system, EGNOS (European Geostationary Navigation Overlay Service), is nearing full operation. Several GPS units advertise capability with the WAAS augmentation system, but this is only available in North America.

Handheld GNSS units also provide an estimation of altitude. In basic models, however, altitudinal accuracy can be poorer than horizontal accuracy. If precise altitude data are desired, a more advanced model or good altimeter should be used.

Field computer units with a built-in GNSS receiver provide the greatest degree of positional accuracy and flexibility in navigation. This is combined with the ability to digitally record data in the field. Weatherproof and durable versions of these units are available. Positional accuracy of less than 1 metre can be achieved through post-processing or other methods. Raster maps and aerial photographs can be uploaded onto the unit. The most advanced models can potentially allow editing of preliminary GIS habitat mapping in the field. Otherwise, points and polylines can be saved for later download and integration with the habitat survey GIS in the office. Different data types can be pre-programmed into the unit so that different points can be used to identify locations of rare plant species, habitat boundaries or ecological threats, for example. Prepared data sheets can be filled in while in the field for later download, saving on data entry time in the office and reducing a potential source of error. Training is required to learn to use GNSS enabled field computers, but this is often included in the cost of the unit.

Additional information on the principles and use of GNSS is provided by Kaplan (2005), English Heritage (2003) and the Royal Institute of Chartered Surveyors (2003). Brief guidance on the use of GNSS in the field is provided in Section 6.2.7.

PART TWO
PREPARATION FOR FIELD SURVEY

4
PLANNING AND MANAGING HABITAT SURVEYS

Planning and preparing for habitat surveys should include the steps outlined in Table 4.1. These need not be taken in the order shown, as the habitat survey team can assist in developing survey objectives and delineating the survey area.

Table 4.1: Outline of Steps in Planning and Preparing Habitat Surveys

Step	Tasks	Section
1. Determine survey objectives	Identify size of survey area	4.1 & 4.2
	Determine data to be collected during field survey	4.1
	Decide proportion of survey area to be covered by field survey	4.2
2. Decide on project management structures	Appoint project steering group, if required	4.3.1
	Appoint project team	4.3.2
	Provide required skills and training	4.3.3
3. Prepare for field survey	Finalise survey methodology	4.4.1 & 4.4.2
	Consider land access	4.3.1 & 4.4.1
	Divide survey area, if required	4.4.2
4. Prepare project data management procedures	Determine data presentation objectives	4.5.1
	Determine data circulation protocols	4.5.2

4.1 Survey Objectives

Prior to the undertaking of a habitat survey, the reasons for conducting the survey, including desired outputs and how they will be used, should be clearly articulated. The objectives of the habitat survey will determine the survey scale and the key pieces of information that must be gathered; these in turn will affect the resources that will be required to meet the survey objectives. How a particular habitat survey should be conducted to meet the desired objectives must be determined by those commissioning and carrying out the survey.

Two contrasting types of habitat survey are: 1) detailed habitat mapping at the site scale, on the order of 1-10 km^2; and 2) broad-scale habitat surveys covering tens to hundreds of square kilometres (10s-100s km^2) for strategic planning or other purposes. How the objectives of these two types of survey influence the types of data to be collected and survey methodology is discussed in this section (Table 4.2). A decision tree illustrating how habitat survey objectives influence the size of the survey area, delineation of survey areas, and level of detail required in data gathering is presented in Figure 4.1. Habitat survey projects may also have intermediate or a combination of objectives and survey scales, such as a strategic survey in which more detailed habitat mapping of a subset of important sites is carried out.

Research-oriented projects are discussed more briefly due to the variation in methodology in this type of habitat survey. In addition, habitat surveys are only one of a number of different kinds of ecological survey, and habitat survey alone may not be sufficient to meet all the objectives of a particular project or plan.

Interface between improved agricultural grassland and upland habitats [The Heritage Council]

Table 4.2: General Characteristics of Strategic and Site-based Habitat Surveys

Parameter	Strategic Habitat Survey	Site-Based Habitat Survey
Typical key objective	Habitat map of large area for forward planning	More detailed habitat data for site management or impact assessment
Size of survey area	Usually larger (10s – 100s km^2)	Usually smaller (1 – 10km^2)
Level of field survey	Field survey may be targeted at habitats of particular interest	Field survey of entire site
Number of field surveyors	Possibly multiple teams	Fewer
Level of species recording and other notes	Usually limited to habitats of interest	Higher
Minimum mappable habitat size (Section 6.2.1)	Larger	Smaller

This Guidance focuses on classifying habitats at level 3 of the *Guide to Habitats* scheme. However, recording or presenting habitats at levels 1 or 2 may meet the objectives of some strategic habitat surveys. *Guide to Habitats* level 3 classifications can always be presented in maps, reports and summary statistics as level 2 or level 1 classification where appropriate (see Chapters 7 and 8 for discussion of spatial analysis and data presentation). However, initially recording data at levels 1 or 2, while allowing a greater survey area to be covered, does significantly reduce data quality, accuracy and precision. The decision to record only at level 1 or 2, and the implications of this, should be discussed during project design.

Strategic habitat surveys can be carried out by local authorities or other bodies to inform strategic planning and development management. For this type of survey, the chief objective is usually to compile a map of habitats for a relatively large area (Figure 4.1), on which decisions about forward planning may be based. In this case, it may be appropriate to focus resources on achieving efficient coverage of as wide a survey area as possible. Information on species composition and target notes for most habitats may then be decided to be of lower priority (but should not be neglected within habitats that are of ecological interest). Greater reliance on remote mapping methods (Section 3.2.3) and reducing the resolution at which habitats are mapped (Section 6.2.1) may be acceptable trade-offs to increase the area covered, depending on the level of detail required to meet the survey's objectives, *i.e.* what has been determined to be required to inform forward planning decisions effectively.

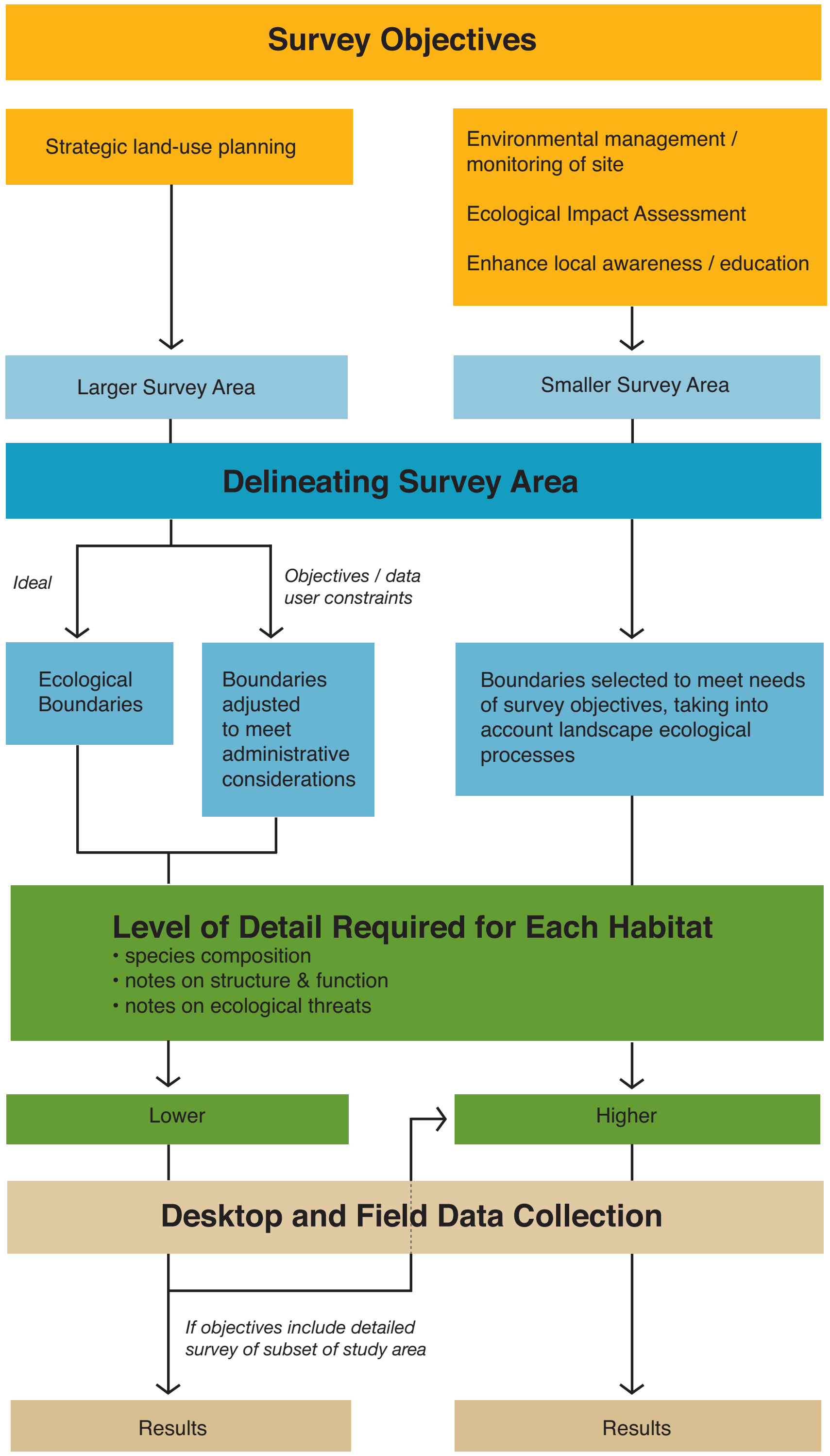
The objectives of a strategic habitat survey may require more detailed information to be collected on a subset of habitats within a survey area (Figure 4.1). For example, the survey area may include sites of known or potential conservation interest, and collecting more detailed information for these sites should be considered. While such studies will assist the habitat survey commissioner in identifying areas of local biodiversity value, they do not remove the need for undertaking detailed ecological assessments where appropriate.

Surveys of individual sites for the purposes of conservation management or ecological impact assessments should focus on detailed recording of habitat location, extent, composition and structure (Figure 4.1). These surveys are often, but not always, smaller in geographical scale than strategic land-use planning surveys, and thus high levels of precision and detail are generally feasible. In some situations, this may not be the case (*e.g.* management plans of large upland sites), and some degree of detail may need to be sacrificed, as in broad-scale strategic habitat surveys; however, this can be supplemented by selecting sub-sites for more detailed survey work. Reference to the survey's objectives should always be made when determining the level of detail of data collection in order to ensure the data collected is fit for purpose.

For both types of habitat survey, evaluating the nature conservation importance of habitats, assessing their ecological condition, and identifying threats to their ecological integrity may be important objectives. Habitat survey projects in which collecting these data are important include those that aim to identify sites of conservation interest, EcIAs, and conservation management projects. Recording habitat evaluation, condition, and threats is discussed in Section 8.3.

The methodology of habitat surveys carried out as part of ecological research will be dictated by the objectives of the wider programme. Careful consideration must be given to how fundamental aspects of the habitat survey should be tailored to meet research requirements. It is likely that the goals of such research projects may require classification of habitats following a system that is more tailored to the individual project (*c.f.* Box 3). However, it is recommended that habitats also be classified according to the *Guide to Habitats*, if feasible, to assist in building the Irish habitat map resource. Other elements of habitat surveying discussed in this volume, such as habitat evaluation methods, may not be appropriate for research-oriented surveys; however, those conducting such surveys may nonetheless find discussion of these topics useful.

Figure 4.1: Decision Tree for Planning Habitat Surveys



4.2 Delineating the Survey Area

In many cases, delineating the survey area will be relatively straightforward. In others, long-term plans for habitat data gathering may mean that there is some flexibility in the delineation of areas to be surveyed in individual projects.

For site-based surveys, the survey area will obviously include the site that has been identified for conservation or development. Depending on the objectives and context of the survey, the survey area may be influenced by such considerations as administrative, land ownership or historical boundaries. Habitat surveys for EcIAs should include all land in the vicinity of a proposed development that is within the developer's ownership, as mitigation measures outside the immediate development site may be required.

Species-rich grassland near Dingle, Co. Kerry [The Heritage Council]

A site-based habitat survey should also include consideration of the wider area around the site, as the surrounding landscape will affect the ecology of the site and vice versa. The size of the additional envelope of land around the site that is to be considered will depend on the survey objectives and the ecology of the site. In general, the envelope should be of a size proportional to the sensitivity of the environment, connectivity of the site to the wider landscape, and magnitude of the factors at play (*e.g.* all areas that may be directly or indirectly impacted by a proposed development; the receiving environment). As a rule of thumb, the envelope should range from at least 100-500 metres, with increasing size for more sensitive or highly connected landscapes. Wider envelopes should also be used for sites where predicted development impacts are large or where land use surrounding a conservation site is highly developed or intensive. A survey area envelope based on the local catchment(s) should be considered for sites with significant aquatic or wetland habitats. Ecological expertise and understanding of the habitats concerned will be critical in determining the size of the envelope.

For strategic or research-oriented habitat surveys, several competing factors may need to be balanced, including short-term information requirements, resource or logistical constraints, administrative boundaries and ecological boundaries. Where possible, the extent of a habitat survey should correspond with a coherent ecological area. Such areas may be delineated by catchment boundaries or other hydrological areas, soil or geological boundaries that influence vegetation, topographic regions or distribution limits of species of interest. This will allow for a more complete and coherent habitat survey. Ecological boundaries are preferable to political boundaries, including national, county, District Electoral Division (DED) and townland divisions, as these usually have limited relationships with the natural environment. Where habitat surveys ignore ecological boundaries, mapping and evaluation of important habitat types at the edge of the survey area can lead to situations where important areas of interconnected habitat outside the study area are not also considered. Following ecological boundaries may require collaboration between adjoining local authorities or north-south cross-border cooperation.

Another practical consideration is whether a habitat survey should cover a number of smaller areas or a single large one. Assuming either division is ecologically sensible, with the survey area and all other things being equal, surveying a single large area will be more efficient in the use of time and resources. Sourcing external information, desktop mapping and preparations for field survey will take less time where only one area is concerned. Similarly, travel time and associated costs during field survey will be reduced and organisation will be simpler.

4.3 Project Management

The objectives and methods for carrying out habitat survey and mapping projects should be developed through cooperation between those commissioning and those carrying out the survey. The primary responsibility of the survey commissioners is to define the objectives of the study, the end uses for data collected, and the form in which they require the data. Where required, the habitat surveyors can assist in finalising the survey objectives and design. However, the main project management responsibility of the surveyors is to develop a methodology and a programme of work that will achieve the project objectives in a timely and cost-efficient manner.

Project management structures will depend on the size and complexity of the habitat survey project. For larger projects, the survey commissioner may also require the assistance of a project steering group to oversee and advise on project scope, objectives and deliverables. Similarly, the habitat survey team may need different individuals taking on the roles of project manager, GIS specialist and field surveyor(s). For smaller or more straightforward projects, individuals can take on multiple roles, provided they have the required expertise.

4.3.1 Project Steering Group

Where the survey commissioners do not have expertise themselves in habitat surveying, it may be advisable for a project steering group to be formed. This should include members with expertise in ecology, particularly habitat or vegetation recording, as well as members with GIS expertise. Ideally, if the final habitat survey dataset is to be integrated with other GIS datasets held by the commissioning organisation, an individual with responsibility for integration should be included in the steering group. Further membership is at the discretion of project organisers and could include individuals with knowledge of local biodiversity.

In addition to project definition as described above, one of the most important responsibilities of a habitat survey project steering group includes facilitating access to existing habitat and species data. These data may be held by the organisation commissioning the habitat survey or may be held by external parties. The steering group should help the habitat surveyors identify useful data sources and acquire the necessary licences and permission to use them. Existing data sources are discussed in more detail in the following chapter. The project commissioner and steering group members may also be able to assist with negotiating land access.

4.3.2 Habitat Survey Team

The key roles needed in a habitat survey team are project manager, GIS specialist and field surveyor(s) /ecologist(s). For a small habitat survey project, it may be feasible for one or two people with sufficient expertise to fill all these roles. However, for larger surveys, a large number of personnel, including multiple field survey teams, may be required.

The main duties of the project manager will change from project to project but they would typically include:

- Ongoing liaison with the project steering group
- Managing project budget and other resources
- Designing habitat survey methodology
- Sourcing staff to fill GIS mapping and field surveying roles
- Ensuring staff are sufficiently trained to fulfil their roles
- Coordinating consultations with third parties
- Planning field survey schedule and logistics
- Obtaining site access
- Ensuring health and safety measures are in place for field survey
- Overseeing development of habitat database using GIS and other project databases
- Ensuring quality of results during the field survey and in the GIS habitat database
- Supervising completion of habitat survey report
- Interpreting results of habitat survey project according to the project objectives

To fulfil these duties, habitat survey project managers should have expertise both in ecological habitat survey and in GIS. This will ensure that the project manager understands the requirements of both the field survey element and the digital habitat mapping element so that he or she can ensure both are completed to a high standard. The project manager should be familiar with the *Guide to Habitats*, Habitats Directive habitat types, and the ecology of the vegetation communities and other habitats that will be encountered during the survey.

Communication is a crucial responsibility of the project manager, including with the steering group and with members of the habitat survey team. Good communication is especially important with field surveyors based out of the office for lengthy periods.

The main duties of the GIS specialist are digital data capture, management and manipulation of habitat information, including geographical extent and underlying information on habitat identity and other characteristics. The GIS specialist has primary responsibility for the production and management of the GIS habitat database and final habitat maps. He or she can also play an important role in providing preliminary mapping to field surveyors to make the fieldwork component more informative and efficient and in reviewed digital habitat data received from other parties early in the study. For a small, simple habitat survey project, an ecologist with very good GIS skills may be able to perform these duties adequately. However, for larger or more complex projects, a GIS specialist will often be necessary to guarantee quality, accuracy, and timeliness of results.

Field surveyors should be experienced ecologists familiar with the *Guide to Habitats*, Habitats Directive habitat types, Irish vegetation ecology, and the habitat requirements of fauna species of conservation interest. In order to properly identify habitat types and evaluate their conservation value, field surveyors should be capable of easily identifying about 75% of the plant species they encounter. For some habitat types, the ability to identify bryophytes (mosses and liverworts) may also be important. Allocating specific surveyors to specific areas may be required to ensure that certain types of habitats are covered by surveyors with appropriate experience in those habitats. Field surveyors also need to be competent in reading maps, navigating and using GNSS units. The ability to discuss habitat surveying with landowners and members of the public confidently is also invaluable. Field surveyors will need to have a certain minimum level of fitness; the ability to tolerate working outdoors for long periods is essential.

As a general rule, habitat survey and mapping projects should prioritise the ecological aspects of the survey and ensure that good ecological expertise is employed. In other words, a habitat survey should be ecology-led rather than GIS-led. Nevertheless, project ecologists should have a good idea of how GIS data are entered and processed. Similarly, the GIS specialist should understand how the ecologists work in the field. This will greatly aid communication between the disciplines and enable the ecologists and the GIS specialists to work as one team.

4.3.3 Skills and Training

It is crucially important that those who commission habitat surveys ensure that the habitat survey team has the required ecological and GIS expertise. In the absence of widely recognised training in habitat survey and plant identification, evaluating the former can be challenging. Ecological and GIS input on the steering group can assist in evaluating survey team expertise. The team members and their level of expertise should be identified to the survey commissioner who should be in a position to evaluate them properly.

It is important that qualifications are not mistaken for expertise, as recent university graduates may have little or no experience in habitat surveying, and there are many highly skilled botanists with no formal qualifications. Informal apprenticeship, where an experienced and a less experienced ecologist work together in the field, is still one of the best forms of training. Membership of a professional society for ecologists, such as the Institute of Ecology and Environmental Management (IEEM) or the Institute of Environmental Management and Assessment (IEMA) gives some indication of the level of overall ecological expertise, although this does not necessarily indicate expertise in habitat survey. Similarly, many recent graduates with GIS qualifications may have no experience in applying their GIS skills to habitat survey and mapping projects. As with ecologists, many skilled GIS specialists have little or no formal qualification.

Training in subjects related to habitat survey is available from a number of organisations in Ireland and Britain. Regardless of the skill levels of field surveyors, some training for the particular habitat survey project will often be required, as survey objectives and methods can vary considerably. This is especially important where more than one field team will be conducting surveys at the same time. The details of the methodology should be worked through and those aspects requiring subjective assessments must be calibrated among the survey teams. Regular meetings during the field season to discuss issues that arise and agree approaches may be advisable. Consistency in the collection of data is vitally important.

Project-specific training should also include the GIS specialist so that he/she and the field surveyors understand each other's methods and requirements. Recommendations on field data collection methods are provided in Chapter 6 of this Guidance. Topics covered should include:

- Data entry — what is to be entered in the datasheet, codes to be used, structure of data entry, consistent shorthand conventions etc.
- Target notes and species recording — appropriate length of target notes, level of detail to be used, consistent shorthand conventions for species names and abundances etc.
- Photography — resolution and other camera settings, recording photograph ID and photograph metadata
- Protocol upon returning to the office — rewriting notes, making hard copies of datasheets, uploading photographs, storing datasheets and photographs etc.

4.4 Preparation for Field Survey

4.4.1 Planning Field Surveys

Prior to field survey, the data to be collected and the survey methodology should be decided upon. Consideration should be given as to how the final data will be used or presented, as this may influence how data are recorded. Recommendations on field data to be collected are discussed in Chapter 6. For habitat surveys of large areas, a pilot study may help to fine-tune survey methods and highlight potential difficulties.

Field scabious at Irishtown Nature Park, Co. Dublin [Atkins]

Desktop review of existing mapping and supplementary information should be used to target important areas for field survey and to ensure that field survey work is undertaken efficiently (Chapter 5).

For site-based surveys at a smaller (1-10 km^2) scale, all habitats should be surveyed in the field. For larger (10s-100s km^2) survey areas, this may not be feasible. In this case, field surveys should usually prioritise areas that appear to contain semi-natural habitats of conservation interest or areas of importance to the particular survey objectives. This approach is most efficient where large tracts of habitats of low ecological value, such as improved agricultural grasslands, tend to dominate the landscape.

The best time for carrying out habitat surveys is the period from April through September, the growing season for most plants. The optimal survey period may be shorter or different if the survey is to focus on particular habitats or aspects of habitats.

According to the *Guide to Habitats*, classification should reflect the state of the habitat at the time of survey. For example, cereal fields are classified as arable crops (BC1) most of the year, but as tilled land (BC3) after ploughing, and may change to recolonising bare ground (ED3) if left fallow for a period. As a general rule, repeat visits are not necessary for habitat surveying, unless this would clarify any uncertainties or unless required by the survey objectives. Habitat survey reports should include the dates when the survey was carried out and assess whether it was an optimal time of year to survey the particular habitat.

As a general rule, habitats that should always be surveyed in the field include:
- Potential habitats listed on Annex I of the EU Habitats Directive
- Habitat types that are rare or are of conservation significance at the national or county scales
- Semi-natural habitat types that may be uncommon or may be of particular conservation significance in the study area

For broad-scale surveys where certain types of semi-natural habitat appear to be relatively abundant, field surveys should cover a sufficient total area of these habitats so that a good picture of their variation and ecological status is achieved. What proportion constitutes a sufficient area will vary depending on the habitat type and study area. Field surveyed areas can then serve as ground truthing for areas classified on the basis of desktop data.

Land access issues should be considered at the project planning stage and are discussed in Section 6.1.2.

4.4.2 Division of Survey Area

Where the survey area is large, a systematic division will be required to ensure it is fully covered in an efficient manner. This is particularly important when multiple teams of field surveyors are participating in a project. Survey area divisions should be divided up among field survey teams in advance so that the areas and responsibilities are clearly outlined. Survey teams should be allocated adjoining divisions to minimise travel costs and edge matching problems.

The exact choice of how to divide survey areas will depend on the scale and objectives of the survey. One method is to divide the survey area according to OSi digital vector mapping tiles (tile sizes are given in Table 3.1). Each digital map tile has a unique alphanumeric code that can be used for labelling field maps and data sheets. Grids can be created and labelled with the tile codes to produce a master sheet for assigning tiles to teams and for ticking them off when field survey is complete. The sample preliminary habitat map for field survey shown in Figure 6.1 covers an area of 2 km x 1.5 km *i.e.* 1:2500 map tile with the survey division boundary shown in purple. For context and orientation, it is best to show some of the area outside of the survey division on field maps.

An alternative method of dividing the survey area is by using 1 km squares of the Irish National Grid (IG). These are shown in blue on 1:50,000 OSi Discovery Series maps. An advantage of using this system is that 1 km grid squares can be identified by their grid reference.

For some habitat surveys, it may make sense to divide the survey area by administrative boundaries, such as townlands. These divisions may have more relevance for historical land use and may have greater meaning for local residents. For other habitat surveys, it may be more sensible to divide the survey area into ecological units, particularly if the survey area contains discrete blocks of different landscape and habitat types. Surveyors with particular expertise in coastal habitats or upland habitats, for example, can then be assigned to those areas.

Special care must be taken at the edges of survey divisions to ensure that all habitats are mapped. Where different survey teams are responsible for adjoining areas, habitats on or near the edge must be checked to ensure that they have been classified as the same habitat type and that other data have been collected in a consistent fashion (quality assurance procedures are outlined in Section 7.4).

4.5 Managing Project Data

4.5.1 Data Storage

Project data will usually be produced in two forms — digital and hard copy — and both will need to be stored and backed up carefully. Digital habitat survey information should be organised on a project basis, with all information for a particular survey stored in one physical location or computer folder. Digital survey information can include the GIS database, associated databases, and base mapping, metadata, project reports, and photographs, electronic copies of reference documents, correspondence and project management files. The different project files should be further organised in a hierarchical format so that they are easy to find. Earlier versions of files should be retained for backup and review purposes, but should be clearly distinguished from current versions. Regular backups should be made on CD, external drives or other media and stored in a second safe location in case of theft, fire, data corruption etc.

Clear recording of species notes, such as, for example, the range of native and non-native willowherbs, is crucial [The Heritage Council]

Field mapping and notes will be in hard copy, unless handheld field computers are used exclusively. Field data should be entered into the GIS habitat database or other electronic format, as appropriate, as soon as possible after fieldwork. Digital field data from field computers, GNSS units and digital cameras should also be uploaded onto the main office computer as soon as possible and metadata recorded. Where fieldwork occupies several days, uploading and data entry should be regular, ideally on a daily basis. Field mapping and notes, along with other hard copy project information — such as correspondence, reference material and print-outs of final maps and reports — should be filed in one location. The organisation of hard copy and digital data should mirror each other in terms of filing hierarchy, subfolder names etc.

Data management is more challenging for large surveys with multiple habitat surveyor teams, particularly when survey areas are widely separated. One or more field offices may need to be set up temporarily and equipped with laptop computers and other data storage arrangements. Information collated and stored in field offices should be transferred to the main office on a regular basis, preferably weekly, and extra care will be needed to make sure the current data versions are clearly distinguished from superseded versions.

Additional recommendations on data management, quality control, and survey report, maps, metadata, and other project documentation are provided in Chapter 7 and elsewhere in this Guidance.

4.5.2 Data Availability

Habitat survey and associated species data should be made as widely available as possible. Wide dissemination of habitat survey information will enhance public awareness and interest in local semi-natural habitats. Owners of survey data should forward any records of protected, red-listed or otherwise rare species to the NPWS and appropriate NGOs, and surveyors should encourage data owners to allow this. Surveyors must, however, check with those who own the data before relaying information to other bodies or individuals, or should refer any enquiries to the survey commissioner. In addition, the National Biodiversity Data Centre acts as a repository for good-quality ecological data, and data from habitat survey projects should also be lodged there (see Box 5).

Giant rhubarb, a particularly troublesome invasive exotic along the western seaboard [The Heritage Council]

The degree to which habitat survey data are made available publicly will need to be determined at the outset of a project, as this will determine how certain data are collected and presented. Individuals and organisations, including the habitat survey team, that store and control personal information about landowners or other private individuals must also be aware of their legal data protection obligations (refer to the Data Protection Commissioner for further information).

While ownership of habitat survey data usually rests with the body that commissions the survey, and this body may wish to keep habitat information confidential, every effort should be made to make information as freely available as possible. Where projects are publicly funded, project managers must also be cognisant of data management obligations under the INSPIRE Directive.

Data on some habitats or species that are of conservation value, such as endangered plant species or rare breeding birds, may be considered by some to be sensitive[8] and that access to such data should be limited or restricted. However, careful consideration should be given when making this decision. A balanced assessment of the potential benefits of making information publicly available versus keeping data confidential should inform this process. Best practice guidance (Chapman and Grafton, 2008) on making this assessment has been published by the Global Biodiversity Information Facility, which promotes making biodiversity data freely and universally available.

[8] Information on habitats and species considered by NPWS to be sensitive is available at http://www.npws.ie/en/DataPolicy/.

If it is determined that specific species data are to be considered sensitive, careful consideration should then be given to the precision at which potentially sensitive species are presented in maps. The level of public availability of the GIS, other digital data, and the

Nettle-leaved bellflower growing in suboptimal habitat along the banks of the River Nore, Co. Kilkenny [Atkins] project report should also be considered when deciding on data presentation for sensitive species. It may be more appropriate to restrict information on sensitive species to a confidential annex than to include it in a more widely circulated report.

During the field survey, invasive non-native species may also be noted. Records of invasive species should be collected — including location, date and abundance information — and records should be relayed directly to the National Biodiversity Data Centre. The Invasive Species Ireland website[9] contains lists, fact sheets and distribution maps for the most significant current and potential invasive species in Ireland.

There may be copyright issues in cases where habitat survey data incorporate or are based on data from other parties, such as habitat maps constructed using OSi vector mapping as a template (see Section 7.1.2). Such issues must be considered carefully prior to making habitat surveys available to another individual or organisation. Preferably, they should be resolved at the beginning of the project. Further guidance on use and licensing of OSi and other mapping data is given in Section 7.1.2.

Box 5. National Biodiversity Data Centre

The National Biodiversity Data Centre was established in 2007 and is based at Waterford Institute of Technology. One of its six objectives is to:

'Serve as a national repository for biological data. Make good-quality, reliable data on Ireland's biological diversity freely and universally available via the Internet.'

The Data Centre has developed a series of websites and an online mapping system which make biodiversity information freely available to data users. It has also established a National Vegetation Database that serves as a repository for vegetation relevé data. The Data Centre has an ongoing programme of datasets that it makes available on the mapping system.

The Data Centre can play a role as a repository for the safeguarding and collating of habitat survey data. In addition, the Data Centre's mapping system enables habitat maps to be presented as distinct GIS layers on the system, thereby making them available to a wider audience. Commissioners of habitat surveys should consider lodging completed habitat survey data with the Data Centre. Habitat surveyors should recommend this to the habitat survey commissioner where appropriate. When lodging any data with the Data Centre for safekeeping or display, special conditions regarding availability to third parties can be covered in a data-sharing agreement.

Habitat data and metadata deposited with the Data Centre must follow the minimum data structure and quality standards outlined in this Guidance, and will be the subject of a formal data-sharing agreement between the provider and the Data Centre. Further information on submitting and viewing data can be obtained at the National Biodiversity Data Centre's website, www.biodiversityireland.ie

The National Biodiversity Data Centre is an initiative of the Heritage Council and is operated under a service level agreement by Compass Informatics. The Centre is funded by the Department of the Environment, Heritage and Local Government.

[9] *www.invasivespeciesireland.com*

Prior to the commencement of any habitat surveys in the field, a review of existing habitat and species information should be undertaken. Desktop analysis should include information in a variety of different formats, as outlined below and in Appendix C. In addition, consulting with individuals and organisations that may have information on the study area may prove useful. Gathering this information may be time-consuming, but the result will be a more efficient field survey targeted at habitats and locations of potential importance.

Desktop data may be used to prepare a preliminary habitat map to be used in the field to guide survey efforts. Use of a preliminary habitat map has two main benefits. Firstly, it can draw the field surveyor's attention to habitats that should be prioritised for field survey because of their potential conservation value or their difficulty to classify using desktop sources. Secondly, checking and correcting habitat boundaries on the preliminary map can increase precision and save time in the field. Cherrill and McClean (1999a), in an assessment of errors in habitat mapping in the UK, recommend the use of a preliminary desktop habitat map in the field as a means to improve accuracy and consistency of habitat classification and mapping. A potential drawback is that errors in the preliminary desktop map may be overlooked when updating with field data.

When using independent datasets to obtain habitat information, it is important to consider the original objectives behind the creation of the dataset. Quality of data sources and data collection methods, especially for previous habitat surveys, should be critically reviewed prior to use. Quality and value of external data sources should be reported in the final habitat survey report.

In larger habitat surveys, it may not be considered feasible to undertake walkover surveys of all parts of the study area. In some cases, organisations commissioning habitat surveys may decide to commission the production of a habitat map using only remotely collected data or data collected previously, which would be refined by future targeted field surveys. As this would result in a dataset with differing degrees of accuracy in habitat identification, it is extremely important that the quality of the source data and confidence in its interpretation be recorded and reported, as discussed in Section 7.2.

5.1 Geographical Data

Many datasets relevant to habitat survey and mapping in Ireland lack comprehensive metadata (see Section 3.4 and Section 7.5.2 for discussion of metadata). Important features of the dataset to consider as a guide to determining the suitability of the particular dataset are the methods used to capture the data, other dataset lineage details, spatial resolution of the data, sampling strategies used, quality of the data collected, temporal reference, and owner of the dataset.

5.1.1 Aerial Photography

Ortho-rectified aerial photography is often the most useful source of desktop habitat information (Section 3.2.3). Used in conjunction with other datasets, a good preliminary attempt at habitat classification can be made to facilitate a more targeted field survey.

As land use changes, the detail in the orthophotography will become dated. Therefore it is vital to know the year in which the orthophotograph was taken. The time of year in which an orthophotograph was taken can also be very important in helping to identify habitats. When acquiring orthophotography, it is important to request the imagery's metadata.

Spotted form of Early-marsh orchid (The Heritage Council)

A marsh (MN1) dominated by flag iris [Atkins]

According to the OSi (pers. comm.), metadata available for OSi orthophotography includes:

- Date on which image was flown
- Time at which image was taken
- Camera type
- Height at which image was taken
- Image reference number

Oblique aerial photographs are images taken where the camera direction is at a non vertical angle to the ground beneath. Oblique aerial photographs may be available for major development lands. Other oblique aerial photographs are held by the Office of Public Works (OPW) for flood risk areas and by NPWS for site monitoring.

5.1.2 Discovery Series Mapping

When carrying out a desktop review of geographical data, Discovery Series mapping (1:50,000) may be useful as background mapping. On its own, it is generally not helpful for identifying habitats, but inspecting topographical contours in conjunction with orthophotography can aid in distinguishing upland and lowland habitats and identifying areas likely to be well-drained or poorly-drained. Digital Terrain Models (DTMs) can be used for the same purpose if they are available for the area or are specially commissioned.

5.1.3 Digital Datasets

A number of GIS datasets exist that contain habitat information or other environmental information that may be useful in identifying potential habitats within the survey area or compiling a preliminary habitat map. Most of these datasets are available at no cost; however, their use is generally subject to a user agreement. These datasets are described in Appendix C.

5.1.4 Interpretation

Interpreting desktop data can be challenging, partly due to the variation in precision, accuracy and quality of available data. Some data can be directly translated into preliminary habitat types, such as habitat maps in management plans or Environmental Impact Statements (EISs), as well as some of the information in the EPA indicative habitats database and the Forest Service database. These data should still be validated by field survey, as the information may be of uncertain quality (*e.g.* solely based on remote sensing data) or may be outdated.

Other data sources require interpretation in order to determine habitat types within particular areas. Aerial photography is very useful for identifying habitats of low conservation value, such as intensive agriculture, and mapping field boundary habitats. Not all habitats can be identified from aerial photography, and different habitat groups are identifiable to different levels of the classification hierarchy in the *Guide to Habitats.* It is not possible to map all habitats to level 2 or even level 1 of the *Guide to Habitats* hierarchy with absolute confidence using only desktop data sources. For example, different wetland habitats — including fens and flushes (PF), swamps (FS), wet grassland (GS4) and marsh (GM1) — are difficult to distinguish using orthophotography and supplementary datasets. Therefore, any habitat mapping project relying solely on desktop data should clearly specify the level of confidence to be placed in assigning particular habitat types to a given area (Section 7.2).

Where possible, orthophotography should be interpreted in conjunction with other datasets. Soil mapping and geological information can provide useful clues. Similarly, topographical contours on Discovery Series maps or DTMs can indicate whether a habitat is likely to be on well- or poorly-drained soils. Historical mapping, such as 6-inch maps, provides some habitat information and can also provide a land-use context that is useful for interpretation, but features may have altered.

If a preliminary habitat map is being prepared for verification in the field, classifications should be noted within the GIS attribute table as deriving from desktop data only. Recommended codes are outlined in Section 7.2.

5.2 Non-GIS Habitat Data

In addition to the GIS-based information sources discussed above, other non-GIS sources of habitat information should be reviewed to inform the preparation of the preliminary habitat map. These sources of information include published research papers, published or unpublished reports, species records in printed or electronic format, academic theses, NPWS data and maps in hard copy, and Environmental Impact Statements (EISs). A list of suggested sources of habitat data is provided in Appendix D, but this is by no means comprehensive.

The literature specific to a county or region should be reviewed. County floras and books dealing with the avifauna of particular counties or regions often highlight localities that support extensive semi-natural habitat or other habitats of conservation interest that should be targeted during field surveys. Some local authorities have produced bibliographies of ecological data sources relevant to the local area as part of Biodiversity Action Plans (BAPs). Often, BAPs also identify habitat types (or locations) and species considered to be of conservation importance in the county or locality. Habitat survey projects should note these, but should not neglect the opportunity to test these by comparison with the results of the survey.

The National Biodiversity Data Centre serves as a repository for biological data in Ireland (Box 5) and also makes biodiversity information available via websites and an online mapping system (http://maps.biodiversityireland.ie). The Data Centre has acquired many species datasets encompassing a number of taxonomic groups, in addition to a large number of vegetation relevés. Most data made available are presented at a scale that is too coarse to provide information for particular habitats. However, these data can be useful in highlighting significant species (*e.g.* rare, protected or invasive species) in or near the survey area that field surveyors should note if encountered.

EISs and other ecological reports relating to developments are other sources of site-specific ecological information. They can be obtained from local authorities. However, as many EISs are followed by the development of the area dealt with, the ecological information provided may not correspond to the present-day ecological conditions of the site.

5.3 Consultations

Information about habitats and species in a particular area can also be obtained from various individuals and bodies. Local and regional NPWS staff are often aware of habitats of conservation interest both inside and outside designated areas. Local Authority Heritage and Biodiversity Officers, where they exist, may also be good sources of information.

There are many NGOs with ecological or heritage interests, such as biological recording organisations and local nature trusts, that may have information on sites or species of interest within a study area. Most NGO members are involved on a voluntary basis, and habitat surveyors should take cognisance of this when requesting information and understand the time implications of their request. For a number of reasons, NGOs and their members may not be able or willing to share data, especially if these are substantial, such as long lists of species records. If more extensive assistance is required from a local recorder or NGO, it may be advisable or necessary for the habitat survey team to enter into a more formal arrangement with them, such as an exchange of data or a sub-consultancy agreement.

Landowners and other local people may have useful information on habitats and species in the area. Landowners are particularly valuable sources of information on past and present land management practices that may have influenced habitat composition and conservation value. More extensive public consultations via articles in local media, posters, approaching local groups, producing a leaflet with project aims for circulation to local people or public meetings can be beneficial, particularly if increasing public awareness of ecology is part of the survey objectives. Broad engagement with the public can contribute to positive attitudes towards biodiversity and conservation, particularly at a local scale. While it is outside the scope of this document to provide specific guidance on this topic, following the available best practice guidance on public participation is recommended.

PART THREE
HABITAT SURVEYING IN THE FIELD

6 FIELD SURVEY

Identifying habitat types according to the *Guide to Habitats* and Habitats Directive habitats classification schemes and mapping their extent is the most important goal of the field survey. The field survey may also require gathering more detailed information on the species composition and structure of habitats, conservation value, threats, and other data. The types of data to be collected in the field will vary according to the survey objectives and the resources available to the project (Section 4.1).

The survey rates of fieldworkers undertaking habitat surveys depend on a number of factors, including topography, weather on the day, complexity of habitat types, accessibility throughout the study area, the experience of the survey personnel, and the scale at which the habitat mapping is to be carried out. Survey rates will also be lower where more detailed information than habitat identity and location is collected. The Joint Nature Conservation Committee (JNCC) (2007) determined the average fieldwork rates across ten Phase I habitat surveys for areas throughout the UK to be between 0.8 and 6.5 km^2 per day. These rates are similar to those reported for habitat survey projects in Ireland using the *Guide to Habitats* classification. Teams of two field surveyors working together can increase survey rates by dividing the mapping, recording and other survey duties, and also by separating occasionally (where safety considerations permit) to cover larger habitats. Broad-scale habitat mapping exercises focusing on mapping semi-natural habitats within areas largely characterised by intensive human activity may be able to cover larger areas per day by focusing exclusively on semi-natural habitats.

Table 6.1: Outline of Field Survey Methodology

Step	Tasks	Section
1. Preparation	Assess health & safety	6.1.1
	Consider land access	6.1.2
	Prepare field maps	6.1.3
	Prepare recording sheets	6.1.4
	Prepare field equipment & guides	6.1.5 & 6.1.6
2. Field recording	Determine minimum mappable habitat sizes	6.2.1
	Map habitat locations & boundaries	6.2.2
	Record survey details	6.2.3 & 6.2.4
	Record species and habitat features of value to fauna	6.2.5

Ecological corridor along a depositing/lowland river (FW2) and associated riparian woodland [Atkins]

6 FIELD SURVEY

6.1 Preparation for Field Survey

6.1.1 Health and Safety

At the time of writing, the main legislation for health and safety in Ireland are the Safety, Health and Welfare at Work Act, 2005, and the Safety, Health and Welfare at Work (General Application) Regulations, 2007. These detail the legal requirements for health and safety for employers and employees. Discussion of health and safety issues in this Guidance is purely advisory and is not intended as an interpretation of legal requirements.

Under the Safety, Health and Welfare at Work Act, 2005, every employer is required to carry out a risk assessment for the workplace to identify hazards present, assess the risks arising from such hazards, and identify the steps to be taken to deal with any risks. The employer must also prepare a safety statement which is based on the risk assessment. This is particularly relevant for field survey work. Similarly, the organisation commissioning the habitat survey needs to be aware of their health and safety obligations.

The issue of lone working by ecologists in the field must be considered as part of the site-specific risk assessment. If the assessment concludes that lone working cannot be done safely due to remoteness, terrain, habitat type, time of day, climate, risks to personal safety or other factors, then arrangements for providing assistance in the field must be put in place. Further advice on risk assessments for lone field workers is provided by the IEEM (2006b). These issues should be considered early in the habitat survey project, as they can have a significant effect on resource planning that those commissioning habitat surveys must take into account when estimating budget needs.

Field surveyors should carry mobile phones or similar means of communication, particularly if phone coverage may be poor. A system of check-ins with the project manager should be organised to ensure that he or she knows when and where the surveyors are in the field and when they have left the field for the day.

Field equipment must include protective clothing and other health and safety gear that is appropriate to the conditions of the site to be surveyed and the weather conditions on the day. As site and weather conditions vary considerably and frequently in Ireland, this Guidance cannot provide comprehensive lists of equipment.

6.1.2 Land Access

Land should not be entered without the landowner's permission. In many cases, this is most easily done by direct contact with the landowner on the day. For small sites where the identity of the landowner is known, permission may be gained through the project

Short turf coastal grassland (GA1) often favoured by foraging chough [Atkins] team, but phoning in advance to inform the landowner of who will be on-site is advisable; this will also allow the surveyor to discuss health and safety issues with the landowner, such as the presence of dangerous livestock. If access is denied, the land should not be entered. The IEEM (2004) provides additional guidance for land access.

Where prior contact with landowners has not been made, field surveyors should carry a letter from the organisation commissioning the habitat survey, naming the field surveyors, and explaining the purpose of the survey. Field surveyors should be prepared to explain to landowners the reasons for the habitat survey, the uses to which the survey data will be put, and the degree of public availability or confidentiality of the results. Field surveyors should also always carry proof of insurance and photographic identification and be prepared to produce these documents for landowners. These documents will help allay any concerns landowners might have and will encourage their cooperation in granting access to land or providing information.

Field surveyors should follow the *Access Parameters and Countryside Code* (Comhairle na Tuaithe, 2005). In particular, access to gates should not be blocked, gates should be left open or closed as they are found, and gates, stiles and gaps in field boundaries should be used rather than climbing fences, as this may damage them. It may be advisable for field surveyors to leave their names and mobile phone numbers in car windows so they can be contacted in case their cars are blocking access for large machinery. In all cases, field surveyors should respect the wishes of landowners and the needs of local people.

6.1.3 Field Map Preparation

Maps and aerial photographs of the survey area must be prepared for use and annotation in the field. Surveyors should study all the maps beforehand to become familiar with site access, travel routes and any areas that should receive special attention in the field. Mapping for field survey should include Discovery Series mapping for orientation, larger scale mapping (*e.g.* 1:5000 vector mapping) for annotation, and aerial photography. Polygons showing the minimum mappable habitat size to be used in the survey (Section 6.2.1) can be drawn on the field maps to assist decision-making in the field. Overlaying a coordinate reference system grid on larger scale mapping or aerial photography can aid in navigation in the field when used in conjunction with a GNSS unit.

Where a preliminary habitat map has been prepared, this can be annotated in the field. It is useful to have preliminary habitat mapping overlaid on Discovery Series or OSi vector mapping to aid in navigation. An overlay of preliminary habitats over aerial photography can also be useful. As even translucent or hatched overlays can obscure underlying features in the field, plain copies of maps and aerial photographs without overlays should also be brought into the field.

6.1.4 Recording Sheets

Ecological, conservation and other data should be recorded on a prepared datasheet. An organised approach to data collection will ensure all relevant data are collected and easily entered into the database on return to the office. Preparation of field recording sheets on computer for printing on A4 paper is fairly simple. It is a good idea to print trial copies to make sure the layout makes for easy and legible data recording by hand.

Data recording sheets will vary depending on the objectives and scale of the survey. The columns or variables on the sheet should correspond with those to be used in the digital habitat dataset. If required, and if enough is known about likely species composition prior to the field assessment, a checklist of plant species may be drawn up and included on the datasheet. Definitions of any codes to be used should be provided on data sheets for easy reference if space allows. A sample field recording sheet is presented in Appendix F and is discussed in more detail in Section 6.2.

6.1.5 Botanical References

Reference materials needed for habitat mapping should be prepared prior to field survey. These include the *Guide to Habitats*, this Guidance, and botanical field guides. Bryophyte field guides may also be useful for some surveys or habitat types; however, many species may need to be collected for later identification in the lab. Some useful field keys and other identification guides are suggested in Appendix D, but this list is not comprehensive.

Vascular plant nomenclature should follow Stace's *New Flora of the British Isles* (2010). In addition, the National Botanic Gardens website www.botanicgardens.ie provides checklists (searchable by synonymy) containing English and Irish common names.

These are continually updated and will follow any future revisions to the *New Flora*; these lists form the nomenclature accepted by NPWS and the National Biodiversity Data Centre.

At the time of writing, bryophyte nomenclature should follow Smith (2004) for mosses and Paton (1999) for liverworts in the first instance. As with vascular plants, the National Botanic Gardens maintains an updated checklist of bryophytes of Ireland with current nomenclature. The bryophyte checklist and synonymy are the accepted nomenclature of the NPWS and the National Biodiversity Data Centre and are available from the same webpage as above.

6.1.6 Field Gear

Other essential field equipment should be prepared prior to field survey. As survey objectives and field conditions vary widely, it is not possible to recommend a prescriptive list of equipment. Appropriate clothing for field surveyors depends on the habitats, weather conditions and surveyor preference. Suitable footwear is essential. Surveyors should always carry some food and water, even if the time spent in the field is expected to be brief, as the situation on the ground may dictate otherwise.

Recording equipment should include pens, pencils and clipboards; hard plastic or metal clipboards are best due to their durability. Weather-resistant clipboards with plastic covers and clipboards with storage compartments are also available. Waterproof paper can be useful, and is available as loose sheets and in bound notebooks. Aerial photographs, maps and data sheets can be printed on waterproof A4 paper using a photocopier or laser printer. It is important to verify that a particular brand of waterproof paper is suitable for such use, as some plastic-coated paper can melt and damage printers. Electronic equipment, such as digital cameras and GNSS units, should be checked and recharged, if necessary, prior to field survey. Spare batteries should be brought into the field, if required.

6.2 Field Recording

6.2.1 Habitat Size Thresholds

Three main constraints make detailed habitat mapping of all but the smallest sites challenging: 1) mapping scale and positional accuracy; 2) time and resources available; and 3) the ecological distinction of discrete habitats in the field. Positional errors arise from a number of sources, including the projection used, the scale and accuracy of the base map and user error. During the field survey, accuracy of the GNSS unit can be an additional source of error. Therefore, accurately mapping the boundaries and positions of small habitat features can be very difficult. As time and resources are almost always limited, use of size thresholds for capturing habitat data will help ensure that resources are used efficiently. In the field, all ecologists use a threshold habitat size, whether consciously or unconsciously, below which small habitat patches are subsumed into the natural variation of the larger habitat type. For example, a 1 m^2 patch of outcropping granite in an upland blanket bog (PB3) would not be classified as a different habitat type, whereas a rocky crag or boulder field occupying more than 1 ha would.

Stonecrop and lichen-shrouded rock outcrop noted as a point feature habitat [The Heritage Council]

For these reasons, some minimum threshold size for mapping habitats must be used. Ecological features below this size are either mapped as point features or are subsumed as variation in a wider habitat type. To ensure consistency among different habitat surveys, **recommendations on minimum mappable areas and lengths for habitats are summarised in Table 6.2.** Thresholds between linear and polygon habitats are discussed, as these are closely associated with digitising habitats in GIS.

Minimum threshold sizes used in a habitat survey should be clearly stated in the survey report and metadata (under Positional Accuracy — see Appendix G).

Table 6.2: Recommended Minimum Habitat Size Thresholds

Threshold	Recommended Minimum Size	Broad-scale Survey (depending on objectives)	Very Small-scale Survey
Polygon v. polyline	> 4 metre width	> 10 metre width	Dependent on positional accuracy and habitat definition
Mappable polygon	400 m^2	2500 m^2	
Mappable polyline	20 m	50 m	

Recommended Minimum Sizes

A minimum mappable polygon size of 400 m^2 or 20 x 20 metres is recommended. Habitat patches above this size should be mapped as separate polygons. Habitat patches below this size should be considered as part of the variation inherent in semi-natural habitats. However, if a small habitat patch is found to be notable during the field survey, it should be included in the point layer of the GIS database. For example, springs (FP) are usually smaller than 400 m^2 in size and should be mapped as point features.

A minimum mappable linear habitat length of 20 metres is recommended. Shorter linear features should be subsumed into the natural variation of the surrounding habitat, or recorded as a point feature if they are of interest. This will result in fragments of remnant hedgerow or treelines of only three or four trees not being mapped as linear features.

There are some cases in which different minimum area and length thresholds should be employed. Although the 400 m^2 area is suitable to cover small-scale variation in most habitats, it may be too small for some habitats or landscapes that are more heterogeneous. In these cases, a 2500 m^2 (0.25 ha) or 50 x 50 m minimum threshold size is recommended. For example, a stand of birch on flushed peat approximately 30 x 30 m in size within an oak-birch-holly (WN1) woodland could be considered part of the main woodland matrix, but one with dimensions twice as large could be considered a pocket of bog woodland (WN7).

Large Survey Areas

In a broad-scale habitat survey covering 10s-100s km^2, survey and mapping of habitats in the field to the above level of precision may not be required, depending on the survey objectives. In this situation, **a minimum threshold size of 2500 m^2 (50 x 50 m) could be used, if this would meet the objectives of the survey.** Similarly, **minimum length of linear features to be mapped could be 50 m.** Features of note that are smaller than these sizes can be recorded as point features.

The 400 m^2 minimum mappable size referred to above is based on the smallest quadrat size recommended by Kent and Coker (1992) for capturing variation in woodland habitats; recommended quadrat sizes for other habitat types are smaller. The larger 2500 m^2 minimum mappable size is based on the larger quadrat size recommended by Kent and Coker (1992) for capturing variation in woodland habitats. These minimum mappable habitat sizes are within the precision tolerances of OSi mapping and standard GNSS units. On 1:5000 vector maps, 20 m = 4 mm, and on 1:10,560 6-inch maps, 20 m = 1.9 mm. Accuracy of standard GNSS units usually ranges from 5-15 metres and is often worse under woodland canopies. Thus, mapping polygons any smaller than 400 m^2 would be difficult to do with precision.

Orchid-rich calcareous grassland (GS1) along a roadside verge in the midlands [The Heritage Council]

Fine-Scale Mapping

Fine-scale mapping of habitats may be desired in urban habitats or for EcIAs of sensitive habitats. If appropriate mapping or GNSS accuracy are available, accurate mapping below the recommended minimum mappable sizes may be feasible. In urban areas, OSi vector mapping at 1:1000 is available to improve mapping accuracy. Engineering survey data may provide a suitable baseline for a fine-scale habitat map. GNSS units with high positional accuracy (less than 1 m error) may be available for use. Using these tools, it may be practical to map very small habitat patches and show linear features, such as hedgerows, as polygons in a map. However, combining data sources of differing scales and degrees of precision will reduce data quality, such as overlaying a Special Area of Conservation (SAC) boundary (derived from 6-inch mapping) onto features from a high-precision engineering survey. The metadata for each dataset should be reviewed and a decision made on its fitness for inclusion in the project, taking dataset quality, precision and accuracy into account (Section 3.4).

Habitat classification becomes more difficult at fine scales, and this should also be considered before embarking on highly detailed habitat mapping. As habitat area decreases, the number of species also decreases, resulting in fewer species or individuals able to characterise the habitat. As an extreme example, defining a 5 x 5 metre clump of trees as woodland would be nonsense. It is not possible to recommend a single smallest mappable area below which habitats cannot be identified, as this will depend on the habitats involved. Kent and Coker (1992) provide recommendations on minimum quadrat sizes to be used for recording vegetation in different habitats, which may inform decisions on minimum mappable sizes for fine-scale habitat surveys.

6.2.2 Field Mapping

Field habitat maps should be clearly annotated so that habitat boundaries and linear features are easily visible and annotations are legible. An example of a marked-up field habitat map is shown in Figure 6.1. Some recommendations on mapping annotation conventions are suggested below, but these should be adjusted to suit the conditions of each habitat survey:

- Mark each habitat polygon and linear feature with a unique habitat number corresponding to a note on the field data sheet (see Figures 6.1 & 6.2, for example).
- Where a preliminary habitat map has been prepared and the preliminary habitat identification is correct, mark the habitat with a tick.
- Areas not surveyed in the field can be marked with *U/S* if they are the exception; otherwise, the map may get too cluttered.
- Where a habitat type is assigned in the field, such as an improved agricultural grassland (GA1), but no further notes are necessary, the new habitat code can simply be noted on the field map.
- Clearly draw habitat boundaries as a solid line and clearly differentiate habitat polygons from their surroundings.
- Strike through boundary features on the base map that do not correspond with linear habitats with two parallel ticks or lines '//' (*e.g.* where field boundary hedgerows have been replaced with wire fencing).
- Special identification and notes on site boundaries are not necessary for most habitat surveys; where additional information on the location and nature of site boundaries is required, see guidelines provided by Lockhart *et al*. (1993).
- Use fine-tipped permanent markers or waterproof pens in different colours to highlight different habitats, especially adjacent linear habitats.
- Where only part of a *Guide to Habitats* habitat type can be assigned to a Habitats Directive habitat type, the areas should be mapped separately so the extent of the Habitats Directive habitat type is clear.

6.2.3 Field Notes

Field notes must provide enough information to meet the minimum criteria for a habitat record (Table 7.2), quality assurance requirements, and the particular objectives of the habitat survey. As discussed in Section 6.2.2, all information should be entered on prepared data sheets to ensure it is collected consistently. The minimum information that should be recorded on field data sheets includes:

- Field surveyor's name(s)
- Survey date
- Name or number of site or survey area division
- Habitat parcel number corresponding to the field-annotated map
- Habitat type according to the *Guide to Habitats*
- Habitat type according to Annex I of the Habitats Directive
- Survey method (recommended codes for different levels of confidence in the habitat data are presented in Section 7.2)

As noted in Section 6.2.2, the classification of habitats of little or no conservation or other interest can be annotated directly on the habitat map, rather than labelling with a habitat parcel number for cross-reference to information on the field data sheet.

Additional data should be collected in the field to meet the requirements of the habitat survey. Examples are given in Figures 6.2 and 6.3 and in Table 7.3.

For habitats of little or no conservation interest, this minimum level of detail should be sufficient to meet the objectives of most habitat surveys. For habitats of higher value or complex habitats, additional notes will usually be necessary. Field notes can include such data as species composition, habitat structure, habitat features of value for fauna, conservation status and site management. Notes may also describe photographs taken, such as the position of where the photograph was taken or details of what the photograph shows. Some habitat survey guidance (*e.g.* JNCC, 2007) distinguishes short notes on a few key species and other features of a habitat from 'target notes', which are more comprehensive descriptions of a habitat. The only real difference is the length of the note and the amount of time spent describing the site(s). As habitat descriptions, even brief notes can be time-consuming; the amount of supplementary detail to be recorded should be carefully considered in light of the survey objectives. Target notes should be clearly linked with habitats on the field map using a number or a letter. If required, locations of target notes for point features can be identified with a numbered symbol, such as a dot inside a circle.

6.2.4 Species Recording

Characteristic and Abundant Species

Most habitats are defined and described in part by the plant species they support. The amount of detail used in species recording depends on the habitat survey objectives and time available, in addition to the ecological interest of the particular habitat. For most habitat surveys, recording a few abundant or characteristic species in the more interesting habitats is usually sufficient. Some projects may require more comprehensive inventories of plant species or more detailed vegetation data; however, this level of recording represents a botanical or vegetation survey rather than a habitat survey. Vegetation survey is briefly discussed in Section 8.4.2, but detailed advice is beyond the scope of this Guidance.

When deciding what species to note in a habitat survey, the distinction between abundant species and characteristic species is important. Some species can be abundant or dominant in more than one habitat type and are therefore of little use in distinguishing among different types. For example, purple-moor grass (*Molinia caerulea*) can be a major component of wet grasslands (GS4), poor fens and flushes (PF2), wet heath (HH3), and upland, lowland and degraded blanket bog (PB2-5). Abundant species should be noted, nonetheless, as they strongly influence habitat structure and can indicate degraded

Rush and purple moor-grass dominated wet grassland (GS4) [Atkins]

Cutover lowland blanket bog (PB4) regenerating in cut basins often dominated by cotton grasses [Atkins]

ecological conditions. Bryophytes should be treated the same as vascular plants, and should be noted where they are particularly abundant or characterise the habitat.

Characteristic species should also be noted. 'Characteristic species' in this Guidance is used in a general sense as species that provide useful information in understanding the ecological processes and conservation value of a particular habitat. These are species that indicate: 1) particular habitat types; 2) conservation value; 3) environmental conditions; or 4) management or disturbance. These species should be used to inform evaluations of habitat conservation value and condition.

Characteristic species used to indicate particular habitat types can include phytosociological 'character species' and species listed under the habitat descriptions in the *Guide to Habitats*. The vegetation analysis literature (Appendix D) can provide guidance on characteristic species for particular habitat types.

Species indicative of high conservation value have been called 'axiophytes' by the Botanical Society of the British Isles (BSBI). Lists of axiophytes have been drawn up for some Irish vice-counties, including Co. Waterford (Green, 2008) and Co. Antrim (BSBI, 2009). 'Typical species' of Habitats Directive habitat types used for monitoring under Article 17 indicate favourable habitat quality and are sensitive to changes in the condition of a particular habitat type (European Commission, 2006).

Species indicative of environmental conditions can provide information that can be used to help identify and describe transitional or mosaic habitat types, determine potential causes of vegetation change, or identify unusual combinations of environmental factors that contribute to conservation interest. *PLANTATT* (Hill *et al.*, 2004) is a useful source of information on the environmental preferences and life history of vascular plants. Similarly, species or habitat structures indicative of particular management practices or disturbance can clarify conservation status, condition and the nature of threats to these.

An indication of relative abundance of those species that are recorded should be provided. The more detailed quantitative and semi-quantitative abundance scales are generally not suitable for habitat surveying. The more 'quick and dirty' DAFOR scale is recommended instead. Some general guidance on the divisions of the DAFOR scale is provided in Box 6. More information on character and indicator species is provided in the literature (Appendix D).

Box 6. The DAFOR Scale

The DAFOR scale is an ordinal or semi-quantitative scale for recording the relative abundance of plant species. The name DAFOR is an acronym for the abundance levels recorded: Dominant, Abundant, Frequent, Occasional and Rare. The chief advantage of the DAFOR scale is that it is quick and easy to use. The main disadvantages are the lack of clear definitions for the abundance levels, and the lack of precision inherent in the five-point scale. For these reasons, DAFOR should not be used in recording species abundances in quadrats, but should be confined to surveys of relatively large, non-quantified areas. It is important to note that, while there is no consistent, accepted definition of the levels of the DAFOR scale, some guidance for the levels of the DAFOR scale are suggested below.

Dominant (D):
A Dominant species generally covers more than two-thirds of the habitat. Most habitats do not have a dominant species, but exceptions can include dense bracken (HD1) stands or oak-birch-holly woodland (WN1) with a pure canopy of sessile oak (*Quercus petraea*).

Abundant (A):
Abundant species typically cover between one-third and two-thirds of the habitat. Usually only a few species in a habitat can be considered Abundant.

Frequent (F):
Commonly encountered species seen when walking through a habitat are Frequent. A rule of thumb for evaluating Frequent species is ‘everywhere you look, you see some’ whereas Abundant species are those where ‘everywhere you look, you see lots’.

Occasional (O):
Occasional species generally have relatively low frequency and low cover. However, they do not have to be searched for to be found.

Rare (R):
Rare species are those that are only found once or a very few times during the survey, depending on the size of the habitat. Species cover is also low where Rare species are found.

Species of Conservation Interest

Flora and fauna of conservation interest encountered during the habitat survey should be recorded. These include species:

- Protected under the Wildlife Acts and the Flora Protection Order
- Listed on Annexes II and IV of the Habitats Directive
- Listed on Annex I of the Birds Directive
- Listed in Red Data books or lists
- Considered to be rare or notable at a local or regional level

Information that should be collected on species of conservation interest includes:

- Location (recorded with a GNSS)
- Population size and structure
- Co-occurring species
- Environmental characteristics of the habitat in which the species occurs

As noted in Section 4.5.2, owners of survey data should forward records of species of conservation interest to the NPWS, the National Biodiversity Data Centre, and appropriate NGOs.

As discussed in Section 4.1, the objectives and methods of habitat survey do not include comprehensive surveys for rare or notable species. If these are required by a project's objectives, they can be carried out at the same time as the habitat survey, if feasible, or they can form a separate programme of work.

6.2.5 Habitat Features of Value to Fauna

As with species recording, habitat features of value to fauna should be noted to a level of detail depending on survey objectives and time available. This information can be useful in assessing the potential fauna biodiversity associated with the habitat and thus the overall conservation value of the habitat (Section 8.3.1). Many habitats of limited plant species diversity can support high faunal diversity or populations of rare animals, including parklands with veteran trees, soft coastal cliffs, salmonid streams and old buildings. Field surveyors should be aware of the habitat requirements of rare or notable fauna species that have the potential to occur within the study area.

Locations of small features of potential ecological importance to fauna should be recorded using GNSS. These can include small flushes, veteran trees, areas of bare ground, badger setts, veteran trees, dead wood, old buildings with potential as bat or bird roosts etc.

6.2.6 Field Survey Example

An example of a data sheet completed in conjunction with the map in Figure 6.1 is shown in Figures 6.2 and 6.3 and is discussed in this section. This example shows part of a strategic habitat survey of a large area. Survey objectives include collecting information on the conservation value of habitats, their ecological condition, current conservation threats, and presence of rare species. A preliminary habitat map has been prepared using desktop information and is being annotated in the field.

After recording his/her name, survey date, and survey area division, the first note taken by the field surveyor is a unique number for each habitat. This same number is used to identify the location of the particular habitat on the habitat map (Figure 6.1).

Information on the quality of field survey data is important for those using the results of the habitat survey. In the example, the second column in Figure 6.2 records the level of precision with which the habitat has been surveyed. In Figure 6.2, this information is summarised as to whether the habitat has been *validated (V)* in the field or whether it has been *surveyed (S)* in more detail, following the recommendations in Section 7.2. The *validated (V)* value indicates that the habitat has been subject to a brief assessment of the habitat type without collating rigorous species lists and ecological features of the habitat.

Species-rich wet grassland (GS4) with abundant ragged-robin [The Heritage Council]

This can include a look over the hedge or across a field or two. Habitat numbers 3 and 4, classified as the conifer plantations, were quickly validated in the field, as a more extensive survey of the habitat was not necessary to meet the survey objectives. A value of *surveyed (S)* indicates the habitat has been subjected to a more detailed walkover survey and recording of other ecological features. Habitat number 1, a raised bog, was *surveyed (S)* during the habitat assessment due to the ecological value of the habitat. In this example, habitats not surveyed or validated in the field would be marked as one of the desktop codes (DA – DD) in the GIS attribute table (see Table 7.2 or Figure 6.2, for example).

In Figure 6.2, the 'Fossitt Code' column identifies the habitat type according to the *Guide to Habitats*. Habitat number 6 is identified as a wet grassland (GS4) and scrub (WS1) mosaic by noting both habitat codes separated by a slash (see Section 6.3.3 for guidance on recording habitat mosaics). This is followed by the 'Annex I Code' column which identifies the habitat type according to Annex I of the Habitats Directive. The Annex I habitat type is given as the standard four-digit code (European Commission, 2007). In this example, other habitat affinities are given in the notes. For example, the raised bog habitat is referable to the western ecotype of raised bog, following Schouten (1984) (Figure 6.3).

The fifth column in Figure 6.2, 'Listed Spp', indicates whether a protected or rare species has been identified within the habitat. If a rare species is identified within the habitat, a 'Y' is entered and details are provided under the species notes (Figure 6.3). Where possible, surveyors should record a detailed grid reference, survey date and the number of individuals present, and submit these data to the National Biodiversity Data Centre. A list of rare and protected species is available on the NPWS website.

Evaluation of habitats should be an objective of most habitat surveys. There is limited value in knowing an area is wet grassland, for example, without knowing whether it is a species-poor rushy field or if it supports a high diversity of flora and fauna. In Figure 6.2, the evaluation of each habitat type is recorded in the sixth column and is determined in the field during the habitat assessment. In this example, evaluation of a habitat type ranges from *International (I)* conservation value to habitats of only *Local Value* for biodiversity. Habitat evaluation is discussed in greater detail in Section 8.3.

In Figure 6.2, the condition of each semi-natural habitat type is noted in the field using an ordinal scale between 1 and 5. Most of the semi-natural habitats have been classified as being moderate (3). Habitat 1, the raised bog habitat, was given a condition rating of 5, signifying that it is still wet and peat forming, with little drainage or other disturbance. However, habitat 19, although of international conservation value as an Annex I habitat, is in poor (2) ecological condition due to water pollution and encroachment by development. The methods used for assessing condition will vary according to survey objectives, and are discussed briefly in Section 4.1.

Species-poor rushy wet grassland (GS4) [Atkins]

Where possible, information on the nature of the threats to habitats of conservation value should be provided. In Figure 6.2, the Threats column summarises threats to habitats of High Local (HL) value or higher. In this case, the threats listed follow the codes used in Natura 2000 data forms for assessing the impacts and activities that influence the conservation status of SACs and SPAs (Appendix E). For example, habitat number 19 lists threats as code numbers H02 and E01.03, water pollution and signifying dispersed habitation (ribbon development) respectively as threat types. Ecological threats to conservation of habitat are discussed briefly in Section 8.3.2.

To clearly link photographs taken in the field to particular habitats, photo identification numbers are recorded on the field data sheet under 'Photo ID' in the final column on the data sheet. In this case, the photo ID number is the number of the digital photograph assigned by the camera in the field. When photos are uploaded to the office computer and habitat data are entered into the project database, this number should be replaced with the unique ID number for that habitat in the GIS attribute table. Managing photographs is discussed in Section 7.5.1.

Space for supplementary notes and a brief list of the characteristic or notable plant species associated with the habitat is provided on the reverse side of the field data sheet (Figure 6.3). For example, notes taken on habitat number 1 — the raised bog habitat — highlighted the abundance of *Schoenus nigricans*, a plant species not typically associated with raised bog. In addition, a list of the other abundant and characteristic plant species and an estimate of their abundance using the DAFOR scale are also presented, including *Sphagnum* spp., *Eriophorum angustifolium* and *Erica tetralix*.

Figure 6.1: Sample Habitat Map with Field Annotation

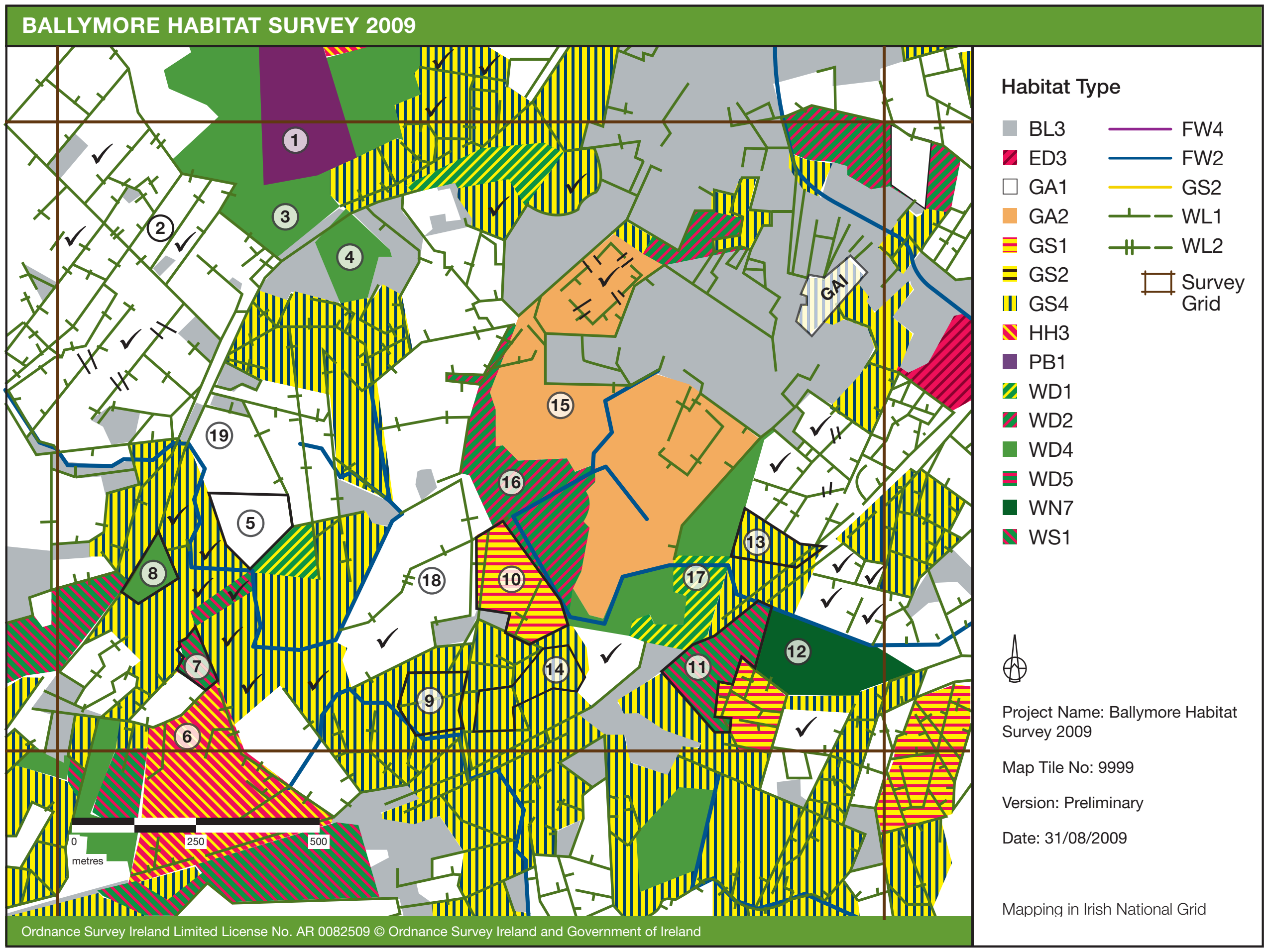


Figure 6.2: Sample data sheet with field annotation (front)

BALLYMORE HABITAT SURVEY 2009

Preliminary Habitat Map No.	Surveyor	Date
9999	A.N. Ecologist	02/09/2009

Hab No.	Data Quality	Fossitt Code	Annex 1 Code	Listed SPP?	Evaluation	Condition	Threats	Photo I.D.
1	S	PB1	7110		I	5	B01.02, C01.03, E03.01	0001
2	S	GS4			LL	3		0002
3	V	WD4			LL			
4	V	WD4			LL			
5	S	GA1			LL			0003
6	S	GS4 \ WS1			LL	3		
7	V	WS1			LL	3		
8	S	WN7			LL	3		0004
9	S	GS3			ML	3		
10	S	WS1			LL	3		
11	V	WS1			ML	3		0005
12	S	WN7			ML	3		0006
13	V	GS4			LL	3		
14	V	GS4			LL	3		0007
15	S	GA2			LL			
16	V	WD2			LL	3		
17	S	WD1			HL	4	I01	0008
18	S	WL1		Y	N	3		0009
19	S	FW2	3260		I	2	H02, E01.03	0010

Data Quality: V = simple validation in field (+/- remotely) S = survey - walkover
Annex I Code: code as per interpretation manual
Listed Spp?: Protected or red data species at global, European or national level. Y or N and name under Species on back
Evaluation: I = International N = National R = Regionally important HL = High Local LL = Low Local O = Negligible
Condition: Ordinal Scale: 1 = very poor, 2 = poor, 3 = moderate, 4 = good, 5 = very good
Threats: Threats to habitats of HL or greater value. Code as per Natura 2000 activities codes and detailed notes on back

Figure 6.3: Sample data sheet with field annotation (back)

BALLYMORE HABITAT SURVEY 2009

Hab No.	Notes	Species
1	Fragment of intact raised bog. Abundance of Schoenus nigricans is unusual for PB1, reflects the raised bog ecotype – western raised bog. Threats – in the form of forestry planting & removal of peat are the main conservation issues	A: Schoenus nigricans, Sphagnum papillosum, Calluna vulgaris F: Sphagnum cuspidatum, Eriophorum angustifolium, Trichophorum germanicum, Erica tetralix
2	Species poor – Rush dominated	Juncus effusus
5	Ungrazed – characterised by rank grasses and tall herbs	A: Filipendula ulmaria, Agrostis stolonifera, Holcus lanatus
6	Forms mosaic with scrub (Gorse) habitat	A: Agrostis stolonifera, Poa trivialis, Juncus effusus O: Ulex europaeus, Molinia caerulea
12	Regenerating semi-mature bog woodland situated on cutover bog	A: Betula pubescens O: Sorbus aucuparia, Ilex aquifolium
15	Golf course – Well-managed, tightly cropped grass species. Fairways fringed by mature lone-standing deciduous trees	A: Lolium perenne O/R: Fagus sylvatica, Pinus spp, Larix sp.
17	Diverse under-storey – threats include Rhododendron invasion	A: Fagus sylvatica, Acer pseudoplatanus F: Q. robur, Luzula sylvatica, Viola spp, Rhododendron ponticum
18	Dominated by Crataegus monogyna and Sambucus nigra. Badger sett identified along this hedgerow	Lamiastrum galeobdolon – Red Data Book plant species
19	Habitat corresponds to the annexed habitat 'watercourses of plain to montane levels with Ranunculion fluitantis and Callitricho-Batrachion vegetation'	Ranunculus penicillatus, Ranunculus aquatilis. Threats to Annex I habitat – dispersed habitation and water pollution from nearby building site

6.2.7 Using GNSS in the Field

In order to improve accuracy of habitat mapping, all field teams should be equipped with a handheld GNSS unit, and training in how to use it. In remote areas, GNSS also provides significant safety benefits. When using a GNSS field unit, it is important that the antenna be unobstructed, and that sufficient warm-up time is allowed for the unit to obtain a good signal from the GNSS satellites. Additional guidance on the use of GNSS is provided by English Heritage (2003) and the Royal Institute of Chartered Surveyors (2003).

Locations of significant ecological point features should be recorded with a GNSS unit. This should include habitats below the minimum mappable size, populations of rare or invasive plant species, signs or habitations of protected or invasive animals, and locations of conservation threats. Coordinates according to the chosen coordinate reference system should be saved to the unit for later upload to the office computer. The positional error reported by the unit should also be recorded and reported.

The use of GNSS-enabled field computers for habitat survey and mapping projects has both advantages and disadvantages. There is a trade-off in time saved on data entry in the office by increased time in the field, as data entry in field computers (using a screen touchpad and stylus) can be time-consuming, depending on the data to be collected. Where field data capture has been well designed (*e.g.* extensive use of tick-boxes), the time saved overall generally outweighs the extra time spent in the field. However, writing lengthy habitat descriptions and recording species without a prepared tick-box style electronic datasheet is unfeasible on field computers. Potential data loss can be a concern with no hard copy backup. However, manufacturers of field computers guarantee data recovery in case the unit is damaged. Data should nevertheless be downloaded regularly, preferably at the end of each field day. If habitat polygons or lines are to be digitised in the field, the field surveyors would need to have the required expertise and good equipment, including a large screen. In addition, digitising in the field may result in reduced spatial accuracy if there are time constraints or adverse weather conditions. It should be noted that the above discussion is limited to the use of field computers for projects focusing on habitat survey and mapping, and that different advantages and disadvantages will apply in the case of other ecological surveys, such as collection of vegetation relevé data.

Invasion of the invasive plant species *Rhododendron ponticum* on peatland habitat [The Heritage Council]

6.3 Habitat Classification in the Field

6.3.1 Guide to Habitats

Interpretation of habitat types in the field may not always be straightforward. In many cases, habitats may prove tough to classify and may not always specifically match a habitat type outlined in the *Guide to Habitats*. These can include transitional habitat types or habitat types that are difficult to distinguish in the field for various reasons. Additional information on variation within and among Irish habitats can be found in the references listed in Appendix D.

Where information on transitional habitats or habitat subtypes is required by the habitat survey objectives, it is recommended that this is indicated by use of a *qualifier* variable in the field datasheet and digital dataset (*FOSSITT_QUALIFER* in Table 7.3). This will provide additional information to the basic habitat type according to the *Guide to Habitats*, but will also keep the basic habitat type codes unaltered in the digital database, facilitating database queries and improving data compatibility from different surveys. Recommended codes are detailed in Table 6.3; *ad hoc* codes can be defined for a particular habitat survey, but should be clearly defined in the survey report and metadata.

Table 6.3: Recommended Qualifiers to *Guide to Habitats* Codes

Habitat Type	Variant Description	Fossitt Qualifier Code
Any habitat	transitional to a second habitat type	(code for the secondary habitat to which the primary habitat is transitional)
GA1	semi-improved or neglected where transitional habitat not clear	SI
GS1	neutral semi-natural grassland	N
GS1	calcareous semi-natural grassland	C
GS4	oligotrophic	O
GS4	base-rich	B
PF1, PF2	fen	E
PF1, PF2	flush	U
HD1	habitat type in absence of bracken[10]	(code for second habitat)
HH1, HH3, PF2, GS3, FS1 etc.	habitats developing on cutover bog[11]	PB4
PB4	industrial cutover bog with no affinities to other habitat types	I
CM1	lower saltmarsh with *Salicornia* and *Puccinellia* species	L
CM1	higher saltmarsh with *Limonium* species	H

6.3.2 Habitats Directive Habitats

Identification of certain Habitats Directive habitat types in the field may prove difficult at times. The NPWS has specialists in certain habitat types who will be able to advise on their identification and classification. *Status of EU Protected Habitats* (NPWS, 2008) provides a useful summary of the Habitats Directive habitats in Ireland. While this publication is not a guide to identification, it should provide sufficient information to give an overview of each

*[10] For dense bracken (HDI), the habitat present prior to bracken **(Pteridium aguilinum)** invasion or the likely habitat that would result from successful bracken control should be indicated, if possible.*

*[11] According to the **Guide to Habitats**, cutover bog (PB4) should be classified according to the vegetation it supports, if possible. In this case, PB4 should be entered in the Qualifier column.*

Semi-improved variant of improved agricultural grassland (GA1) [Atkins]

habitat type. The status report also presents a map illustrating the distribution of each habitat based on the 10 km grid squares and evaluates the range, area, structure/function and future prospects of each habitat type. Additional information on variation within and among Habitats Directive habitats in Ireland can be found in the references listed in Appendix D.

6.3.3 Habitat Mosaics

Intimate mosaics of different habitats commonly occur in the Irish landscape. These present a challenge to recording and mapping. In some cases, scale of habitat mapping and resolution at which habitat patches are recognised and mapped will determine how mosaics are best handled. Habitat patches within a mosaic that are generally larger than the minimum mappable size being used in the survey should be mapped and classified separately.

Where habitat patches occur at a size that is smaller than the minimum mappable threshold, the habitat should be recorded as a mosaic after carefully considering the ecological significance of the habitat features present and the range of natural variation common in the wider landscape. Recommendations for recording mosaics are:

- List habitats in decreasing order of total cover
- In the GIS database, list habitat codes within the Habitat Type column separated by *space-backslash-space, i.e.* '\'
- Use target notes to describe the composition and spatial structure of mosaic habitats as needed
- Identify habitats as a mosaic only where the secondary habitat covers a significant area
- Follow *Guide to Habitats* guidance on distinguishing between habitat types that frequently occur in mosaic or transition

For example, a dry heath/acid grassland mosaic where the heath component is dominant should be recorded as 'HH1 \ GS3' in the *Guide to Habitats* Habitat Type column (*FOSS_ CODE*, Table 7.2) in the digital habitat database. Additional habitats present in the mosaic should be appended as necessary. The presence of gorse scrub as a minor but significant component of the above mosaic would be recorded as 'HH1 \ GS3 \ WS1'.

Ecotones comprised of mosaics or transitional habitat types frequently occur at the interface between habitat types. Where mosaic or transitional areas are small relative to the area occupied by the adjacent habitats, they are best subsumed into the appropriate main habitat types. Where the transition is more extensive, it may be preferable to identify the area separately as a habitat mosaic or a transitional habitat type. For example, an extensive area of dry calcareous grassland (GS1) may meet an extensive area of limestone pavement (ER2) over a 30 metre wide transition zone comprised of small pockets of grassland, crumbling limestone and dry calcareous heath (HH2). In this case, the transition area may be best mapped as GS1 with ER2 and HH2 present in a mosaic in smaller amounts, *i.e.* 'GS1 \ ER2 \ HH2'.

6.3.4 Urban Areas

The importance of gardens for biodiversity is receiving greater attention (*e.g.* Thompson, 2007; Buczacki, 2007). Habitat mapping in urban areas presents a unique set of practical problems. Habitats of ecological interest are generally small and scattered, and thus have a greater importance than they would in rural areas. Access to habitats on private lands, particularly gardens of private houses, is a significant challenge. Classification of gardens is also difficult; the *Guide to Habitats* includes several habitat types that can occur in gardens, including amenity grassland (GA2), flower beds and borders (BC4), and ornamental/non-native shrub (WS3).

The best way to address these difficulties depends on the objectives of the habitat survey. If an urban or suburban area is part of a larger habitat survey, then mapping urban habitats in great detail may not be the best use of scarce resources. If a minimum mappable area of 2500 m^2 (0.25 ha) is used, this is larger than most private gardens and pockets of semi-natural habitat. In surveys of this nature, urban areas, including gardens and small habitats, should be classified as the appropriate mosaic with buildings and artificial surfaces (BL3), such as 'GA2 \ BL3', 'BL3 \ BC4 \ GA2' etc., depending on the relative abundances of habitats present within the area. Smaller but important areas of semi-natural habitat can be recorded as point features in the urban matrix. The potential for the presence of these should be identified by inspecting orthophotography and by consultations with local individuals and organisations.

Where the survey is focused on a town or part of a city and covers a relatively small area, the minimum mappable area should be reduced in order to capture small habitat patches. As discussed previously, very fine-scale habitat mapping depends on the availability of accurate base mapping and/or highly accurate GNSS units. The difficulties in obtaining

Habitat mosaic consisting of mixed broadleaved (WD1) and wet willow-alder-ash woodland (WN6) [Atkins]

Linear eroding/upland rivers (FW1) running through sheep pasture, Connemara, Co. Galway [Atkins]

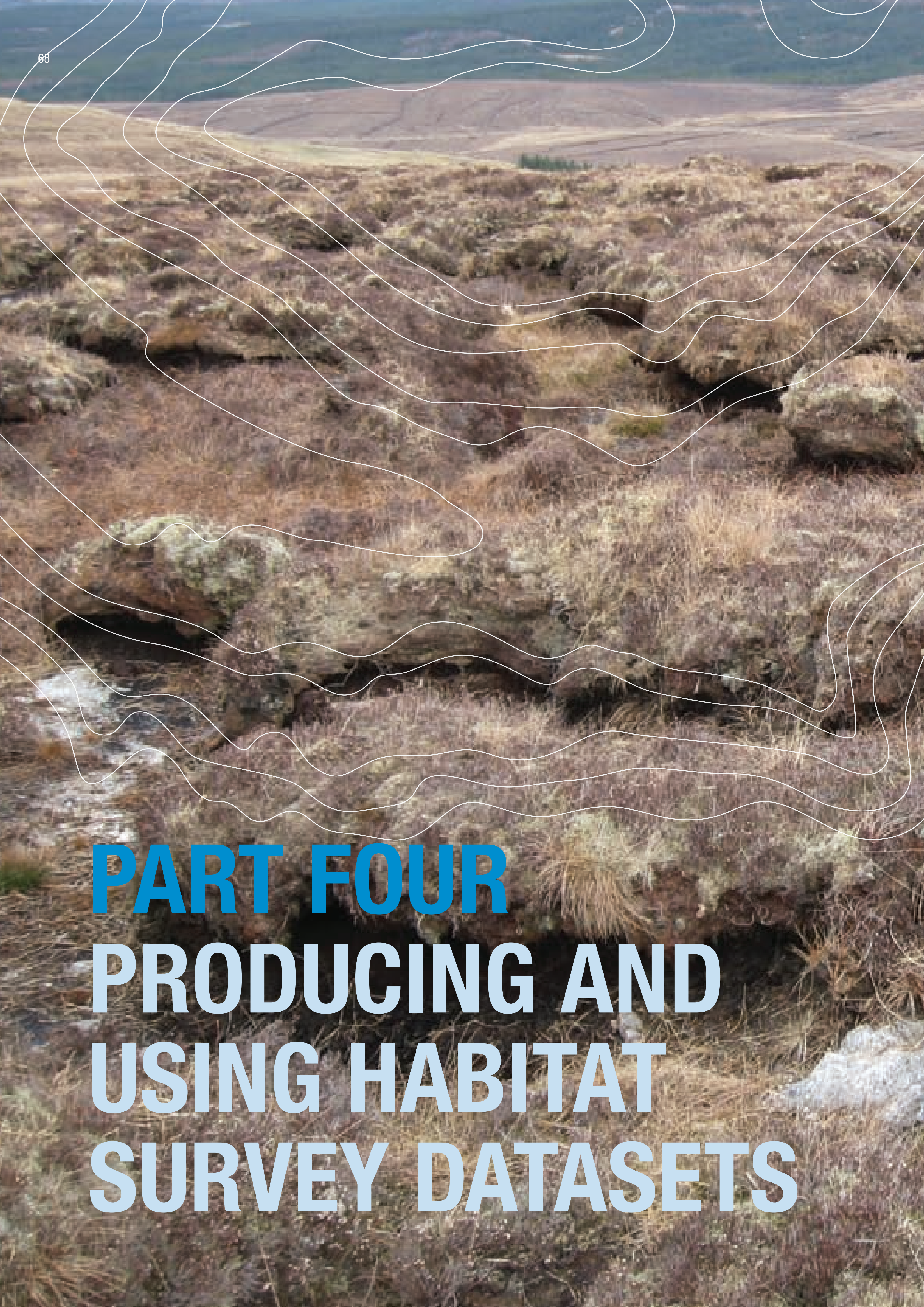
access to private gardens not visible from public areas will, however, remain. If low-flown aerial photography (25 cm per pixel) is available, it may be possible to assign garden habitats to the appropriate type according to the *Guide to Habitats*. If neither field survey data nor detailed aerial photography is available, gardens should be mapped as amenity grassland (GA2), as this is the dominant habitat type in most gardens.

6.3.5 Linear Habitats

Adjacent linear habitats, such as hedgerows, treelines, drainage ditches, stone walls and earth banks, often occur along field boundaries or watercourses. These can pose problems for habitat mapping as they can be difficult to distinguish on maps. Field boundaries on OSi vector maps are usually shown only as a single line, even when they are comprised of more than one habitat type.

When surveying at the site scale (1-10 km^2), adjacent linear habitats should be recorded and mapped separately. Hedgerows often occur on both sides of another linear habitat, such as a drainage ditch, stream or track. In these cases, all linear habitats should be mapped separately.

For broad-scale (10s-100s km^2) surveys, adjacent linear habitats should also be recorded and mapped separately, where possible. However, this will often not be feasible if the resources are not available for a complete field survey of the entire area. In surveys where some habitats are mapped by observation from a distance or from aerial photography, detecting some linear features will be difficult or impossible, for example drainage ditches parallel to hedgerows. In these cases, only the dominant habitat type should be mapped, and the fact that the habitat was mapped remotely should be recorded in the *DATA_QUAL* field. The dominant habitat type is the one that is more structurally prominent, such as a hedgerow adjacent to a drainage ditch or an earth bank on which scattered shrubs occur.



PART FOUR
PRODUCING AND USING HABITAT SURVEY DATASETS

Preparation of the habitat GIS database, any other databases, project report and other outputs should follow the steps outlined in Table 7.1.

Table 7.1: Outline of Steps in the Preparation of Databases and Report Production

Step	Tasks	Section
1. Prepare map structure	Use vector mapping as habitat map template, if desired	7.1, 7.1.2
	Prepare separate layers for mapping habitat polygons, lines and points	7.1.1
	Digitise habitats, where necessary	7.1.3
2. Prepare data structure / attribute tables	Prepare attribute tables for data entry	7.2
3. Compile the database	Review data	7.3.1
	Enter data	7.3.2
	Carry out periodic inspections of data quality	7.4.2
	Carry out field rechecks of subset of habitats surveyed (large projects)	7.4.3
	Carry out review of digital dataset quality	7.4.4
4. Data management	Store and label photographs	7.5.1
	Prepare metadata	7.5.2
5. Present survey results	Write survey report	7.6.1
	Prepare habitat maps	7.6.2

7.1 Map Structure

The coordinate reference system to be used must be chosen prior to commencing habitat mapping, and any digital mapping or survey equipment, such as GNSS units, needs to conform to this coordinate reference system. As noted above, at present, most habitat mapping will use the IG coordinate reference system. However, it is best practice to use the newer ITM coordinate reference system where possible. As this system will eventually replace IG in Ireland, capturing habitat data in ITM will avoid the spatial errors inherent in future conversion from IG to ITM.

Creating the habitat map topology can be done either by: 1) digitising from scratch; or 2) using existing vector mapping data as a template for the habitat map. There are advantages and disadvantages to both methods as discussed below.

When using existing vector mapping data, linear features outlining field boundaries, watercourses etc. are converted into polygons that can be assigned to habitat types and associated with other data at later stages of the habitat survey. The most commonly

Wide depositing/lowland rivers (FW2), River Allow, Kanturk, Co. Cork [Atkins]

available mapping that is suitable for this purpose is OSi vector mapping at 1:1000, 1:2500 and 1:5000 scales. Very rarely, high-precision, highly accurate (often project-specific) mapping may be available and this should be used as a template where possible. Using OSi vector mapping as a template will improve the accuracy and precision of the habitat map, make it more consistent with other baseline mapping and habitat survey maps, and save time spent digitising. The disadvantages are that the process of converting OSi vector data to polygons is more complicated, and access to the resulting digital habitat mapping data will be restricted to those parties that have an OSi licence for the baseline mapping. Combining OSi base mapping of different scales to form a template can result in errors in accuracy and precision.

Digitising the habitat map from scratch can be very time-consuming when large areas are to be covered. In addition, the resulting map will generally be less accurate and consistent with other mapping for the same or adjacent areas. However, digitising the entire habitat map avoids the issue of OSi licensing, and it may be more cost and time-efficient when mapping habitats in small sites.

The choice of methodology depends on the objectives of the habitat survey project, the final recipients of the data and the area to be mapped. In general, using OSi vector mapping data as a habitat map template is recommended, particularly for larger habitat survey and mapping projects. Detailed guidance on digitising and converting OSi vector data is provided in Sections 7.1.2 and 7.1.3.

7.1.1 Mapping Polygons, Lines and Points

Habitats that are best depicted as a discrete area in two dimensions, such as woodlands, fields and bogs, should be represented by a polygon feature in the GIS habitat map. Linear habitats, such as narrow watercourses, hedgerows and treelines, should be represented by polyline features (*i.e.* a connected series of line segments). Very small habitats, such as springs, and point records of notable species or other ecological features should be represented as point features in the dataset. **Each of these spatial feature types must be stored as a separate layer or theme — under no circumstance should they be mixed within a GIS dataset.**

Guidance on distinguishing polygons, polylines and points is provided to promote consistency among habitat surveys. Recommendations on minimum mappable sizes for habitat area and linear habitat length are outlined in Section 6.2.1 and Table 6.2.

To distinguish between habitats that should be mapped as polygons and those that should be mapped as polylines (Table 6.2):

- Habitats narrower than 4 metres should be mapped as polylines; wider habitats should be mapped as polygons
- For broad-scale habitat surveys, habitats narrower than 10 metres should be mapped as polylines; broader habitats should be mapped as polygons, where this meets survey objectives

The 4 metre recommendation is based on the width threshold for distinguishing between hedgerows and narrow woodland in the *Guide to Habitats*. The threshold width should be evaluated at the base of the habitat, rather than the canopy width of hedgerows or treelines.

Habitats that will often be mapped as linear features include hedgerows (WL1), treelines (WL2) and streams and drainage ditches (FW). Other habitats narrower than the threshold used should also be mapped as linear features, such as cliffs, exposed rock faces and linear strips of grassland. Where a habitat feature varies in width along its length, the average over the study area or over 1 km, whichever is smaller, should be used to determine how it is mapped.

Rivers in particular may often be included in both the polygon and polyline datasets within the same habitat survey GIS. This can cause difficulties in later data analysis, such as when calculating the total length of watercourses in a study area. To circumvent these problems:

- Information on watercourses (and other habitats, if necessary) **less** than the width threshold should be added to the *polyline* dataset *only* (refer to Section 6.2.1).
- Information on watercourses (and other habitats, if necessary) **greater** than the width threshold should be added to the *polygon* dataset (refer to Section 6.2.1).
- However, in reality, most study areas will include watercourses of varying widths — *i.e.* both below and above the specified width threshold (based on survey objectives). In such cases, information on watercourses (and other habitats, if necessary) **greater** than the width threshold should *also* be added to the *polyline dataset*, *i.e.* double recorded. The best approach is to digitise the centreline of the watercourse from the polygon dataset which should then be stored in the *polyline dataset* as a linear feature. If using OSi vector mapping as a template, as discussed in Section 7.1.2, the centreline of the watercourse may already exist in the baseline vector mapping. This allows you to extract information on watercourses while also being able to present watercourses as a complete feature. Depending on the survey objective, it may be beneficial to have an attribute field in the polyline dataset which differentiates between watercourses which are less than or greater than the width threshold.

7.1.2 Using OSi Base Mapping

Note that OSi mapping is protected by copyright; licensing of OSi and other mapping data is discussed in Box 7.

OSi vector data combine a number of polyline, point and polygon features to form a single layer. Using GIS, it is possible to manipulate these data and extract specific features within the layer to create a preliminary habitat mapping template. **Only the data layers required to form the habitat mapping template should be extracted from the OSi vector mapping product.** Otherwise, extraneous information, such as map frames, townland names or other labels, will be included in the habitat mapping template. Key layers which should be extracted from the vector map include field boundaries, water features, buildings, roads, and other features, depending on the survey objectives. A copy of the original OSi vector mapping should be retained for later use, such as overlaying on the habitat survey data for presentation of small-scale maps.

It is also possible to specify to the vector data provider which features you require, and they may be able to extract specific features and supply a single layer for each feature type. OSi and other data providers can supply data as requested by the customer. These may take the form of several datasets at various scales, datasets which hold a combination of feature types, or datasets which contain specific features such as watercourses. Clients may also request the file format in which they would like to receive the data.

Field boundary features from the extracted layers should be processed to convert the polylines that make up these features to polygons. These polygons will form the basis of the habitat map. To create a coherent, unified habitat map, each separate mapping tile should be merged together once they are converted to polygons. **Note that field boundaries will be 'open' where there is a gate or other gap in the line present**, and these fields will not be converted to polygons until the gap is closed. Therefore, the data must be inspected and field boundary gaps must be manually closed prior to commencing conversion to polygons.

Linear features, such as watercourses and hedgerows, should also be extracted from vector mapping and merged to form a seamless polyline layer.

Care should be taken when extracting feature types from OSi vector data. Other key factors of which one should be conscious include:

- Features that extend from one map tile to a neighbouring tile
- Connected features
- Water features that are interrupted by bridges and culverts
- Rail features that are interrupted by bridges
- Location of the coastline relative to high water marks and low water marks
- Alignment of watercourses

The approach outlined above is scale exclusive, and OSi vector mapping at different scales may be used in the same project, but users must be aware of the accuracy and precision issues which arise from combining mapping which are captured at varying scales. Another issue is the naming of features across the different scales as different feature classes. For example, on a 1:5000 OSi vector tile, buildings are called 'dw_house' (dwelling house), whereas on a 1:2500 OSi vector tile, buildings are called 'solid' (meaning any type of building).

Box 7. Licensing Mapping Data

OSi maps are protected by copyright law. Users of OSi mapping who wish to make copies of OSi mapping in a paper or digital format must: 1) be licence holders; 2) have a copyright permit; or 3) obtain permission from OSi to reproduce OSi mapping. When producing/reproducing maps that are based on OSi mapping in hard copy or in a PDF format, OSi copyright must be acknowledged. Information regarding a suitable copyright statement can be obtained from the OSi website (www.osi.ie). If a map or a report containing OSi maps is to be sold, this must be discussed with the OSi copyright department prior to publication.

A licence holder for OSi digital data (raster and vector) can pass these data on to another party to use on their behalf under a third-party licence. For example, an organisation commissioning a habitat survey who has licensed OSi digital data can provide it to the habitat surveyor under a third-party licence.

When OSi vector data are used as the template for a habitat map, the recipient of a digital habitat map prepared in this way must hold a licence for the baseline OSi vector data. If a licence holder wishes to pass the digital habitat map on to another organisation or individual, that organisation or individual must seek to license the baseline data from the OSi. For example, if a local authority commissions a habitat survey from a consultant, and a university then requests a digital copy of the habitat map which contains OSi intellectual property/mapping, the university must then request an academic licence from the OSi prior to receiving the mapping data.

Provision of GIS datasets by other organisations, such as the EPA and the Forest Service, is also subject to data agreements. The exact terms of data agreements vary among organisations, but normally include restrictions on distribution and commercial use and requirements for acknowledging the source of the data.

7.1.3 Digitising

Even if OSi vector data are used as the habitat mapping template, some digitising will almost always be necessary to produce the habitat map, as habitats often do not neatly follow field boundaries and other man-made land divisions. Where digitising is necessary, it should follow existing OSi vector mapping features, where appropriate. Where no corresponding OSi mapping feature is present, interpretation must be done at a scale appropriate to the resolution of the base map. Working at a scale of 1:1000 or less while digitising from OSi vector mapping, aerial photography and other base mapping at similar scales is recommended for accuracy. Where this is not feasible or realistic, digitising should be done at the nearest appropriate scale.

When digitising, the following rules should be followed:

- Points, polylines and polygon features should be stored in separate layers
- Lines must not cross without nodes intersecting
- Lines that use a common node must intersect exactly — use of the snapping and the auto-trace functions of the GIS can avoid slivers and overlaps
- Adjacent polygons should share a common boundary
- Polygons must be closed — use of the snapping function, set to an appropriate tolerance
- Snapping function tolerance should be set appropriate to the digitising scale
- Polygon boundaries or polyline features should not be self-intersecting
- Holes in polygons should be appropriately ‘punched’ — where there is a habitat completely surrounded by another habitat, the space occupied by the smaller habitat must be digitised as a hole in the larger, surrounding habitat, such that there is a distinct polygon contained within the larger polygon

- Polygons should not extend across roads digitised as polygons unless the adjacent area is categorised as buildings and artificial surfaces (BL3) and the road is an extension of this habitat type
- Polygons should not extend across a wide river or other linear feature mapped as a polygon
- Polygons may extend across areas intersected by polylines in the polyline data layer
- Features should not be 'stream' digitised (stream digitising is the process of manual digitising, of polylines or polygons, where nodes are automatically placed at preset intervals based upon distance or time)
- Where it is not possible or appropriate to digitise a feature boundary following existing vector data, then digitised lines should pass through the centre of any underlying raster feature

7.2 Data Structure

A well-designed database is a collection of information organised in such a manner as to make the information easily accessible. The structure of the database should be simple in order to make storage and retrieval equally easy. A GIS has its own database in which information can be stored, *i.e.* attribute tables containing data associated with the polygons, polylines and points in the habitat map.

The project database files should be given brief but descriptive names and stored in a specified folder along with other project data, including photographs and metadata.

Each habitat dataset should be constructed in a way that makes the data easy to manipulate and amalgamate with other datasets. For this reason, the production of attribute data that are standardised across different habitat survey projects insofar as possible is of importance.

Montane heath (HH4) in Co. Galway [Atkins]

Table 7.2 outlines the minimum attribute fields that should be included in each dataset. For compatibility among different habitat datasets, it is strongly recommended that these attribute names are used. This is the absolute minimum of attribute fields required to constitute a habitat record. Other attributes can be added in the dataset, depending on the objectives of specific projects. Some information collected during the field survey may not need to be incorporated into the GIS database, such as the field surveyor's name.

Table 7.2: Minimum Attribute Fields to be Included in Each Dataset

Attribute	Description
OBJECT_ID	Unique numeric identifier for each polygon, polyline or point in the dataset
FOSS_CODE	Alphanumeric habitat code as per *A Guide to Habitats in Ireland* (Fossitt, 2000)
ANNEX_CODE	Alphanumeric habitat code as per Annex I of the Habitats Directive (European Commission, 2007)
DATA_QUAL	Indication of field data quality. See text for codes
DATE	Date of field survey

An important attribute that must be included in each dataset is the *DATA_QUAL* field. This provides the data user with an indication of the source of the habitat record and the degree of confidence that can be had in the data. The survey method codes to be used to describe decreasing level of quality are:

- **S** = Field data have been collected by *walkover survey*, where the habitat has been walked through by the field ecologist, allowing relatively detailed inspection of habitat structure and species composition. Where only part of a habitat has been surveyed at this level of detail, this part of the habitat can be mapped as a separate polygon
- **V** = Data have been *field validated*, where the habitat has been viewed in the field in less detail, such as over the hedge or inspection through binoculars from a distance
- **DA** = Habitat information is from a *desktop* source that provides recent (*i.e.* within 10-15 years[12]), *high-quality data* that permit a confident identification of habitat type and other data, such as a previous survey carried out as part of a research project or EcIA or information from a trusted third party
- **DB** = Habitat information is from a *desktop source* that provides older (*i.e.* greater than 10-15 years old), *high-quality* data that permit a confident identification of habitat type and other data
- **DC** = Habitat information is derived from *desktop* interpretation of *aerial photography* supplemented by additional data sources of good quality, such as those listed in Appendix C
- **DD** = Habitat information is derived from *desktop* interpretation of *aerial photography only*

Table 7.3 is a sample list of attribute fields which may be useful for many general habitat surveys. Attribute fields used in addition to the minimum fields specified in Table 7.2 should be adjusted or added to meet the objectives of particular habitat survey projects. The use of additional attributes such as County, Electoral District, Townland Name, and Historic Place Names (not listed in Table 7.3) could also increase the interoperability between habitat surveys commissioned by different stakeholders.

[12] What is considered to be recent may differ by project or habitat and should be specified in the metadata.

Table 7.3: Examples of Additional Attribute Fields that can be Included in Each Dataset

Attribute	Description
FOSS_QUALIFI	Qualifier code identifying subtypes or variants of *A Guide to Habitats* (Fossitt, 2000) habitat types; see Section 6.3.1 for discussion
ADD_HAB	Additional habitat classification following a different habitat classification scheme, *e.g.* one listed in Box 3
FOSS_NAME	Habitat name as per *A Guide to Habitats* (Fossitt, 2000)
AREA	Total area (m^2) of polygon
LENGTH	Total length (m) of polyline
EASTING	Easting coordinate of point or centroid of polygon or polyline
NORTHING	Northing coordinate of point or centroid of polygon or polyline
PHOTO_ID	Photo ID number(s)
ANNEX_SPP	Presence (0 or 1) of species listed in Annex II of the Habitats Directive or Annex I of the Birds Directive
RDB_SPP	Presence (0 or 1) of species listed on any Irish Red Data book or list
EVALUATION	Conservation evaluation as per a specified rating scheme
CONDITION	Condition of habitats of conservation interest
THREATS	Threats to habitats of conservation interest following codes in Appendix E
LOCAL_BIOD	Is the habitat an area of biodiversity interest in the study area (0 or 1)?
CORRIDOR	Is the habitat part of an ecologically important corridor in the study area (0 or 1)?
NOTES	Any other comments that are of relevance to the survey
SPECIES	Characteristic or notable species recorded during field survey

Information on species or sites of conservation interest can be recorded under the *NOTES* field. Alternatively, names of species or sites can be listed directly under fields, such as *ANNEX_SPP* or *LOCAL_BIOD*. Such decisions should be made based on the objectives of the habitat survey and the end uses of the data.

Location within an area designated for nature conservation (SAC, SPA or NHA) is an important piece of nature conservation information. However, it is not recommended that this information be included within the habitat dataset. As level of designation and boundaries are subject to change, this may lead to future discrepancies between data layers. Designated area GIS layers of cSAC, SPA, NHA and pNHA site boundaries are available on the NPWS website and are updated regularly. These should therefore be stored separately to allow for updating as appropriate.

Although most modern database software is not case-sensitive, it is good practice to add attribute fields and enter attribute data in a standard way, such as always using lower case letters. Other software or computer languages, particularly older software or software based on older principles, may be case-sensitive when they search attribute tables for data.

GIS databases should be designed to be as simple as possible. This will permit flexibility of analysis and presentation. It is always possible to combine simple data in a presentation or analysis to present more complex information. General guidance to keep in mind includes:

- Each field in the database must relate directly to the subject of the table
- Each table should contain information about one subject
- Underscores rather than spaces between words should be used when naming attribute fields
- Full stops or other punctuation marks or symbols should not be used
- Either lower or upper case letters should be consistently used when naming attribute fields
- All rows must be uniquely identifiable
- Field length, *i.e.* the number of characters that will fit in each field, will be dependent on software choice
- Information should be stored in its smallest logical part, *e.g.* separate fields for habitat code and habitat name
- Attribute fields should not be redundant insofar as possible, *i.e.* they should only contain information not contained or partly contained in other attribute fields

As a GIS attribute table is limited to specific field lengths in some software, it may be necessary to store some information, such as species lists or descriptive notes, using different database software which is able to handle long text strings. If this approach is taken, the *OBJECT_ID* field should uniquely identify the same habitat record in both databases. Habitat records in different datasets can also be hyperlinked, although this is not generally recommended due to the potential for broken links when transferring or restructuring files.

A digital example of a habitat mapping dataset is available for download from the Heritage Council website (www.heritagecouncil.ie).

7.3 Compiling the Database

7.3.1 Data Review

On return to the office, field surveyors should review the data they have collected to ensure that there are no errors or gaps prior to entering the data in the GIS database. If data are to be entered by another individual, it may be necessary to produce clean copies of field-annotated habitat maps and datasheets, especially if rain, mud or bad handwriting make them difficult to read.

Review of the field survey data should be an ongoing process during compilation of the final GIS database. In some habitat surveys, it may not be possible to assign final values for some attribute fields until all data have been reviewed. For example, if habitats are being evaluated in part based on the frequency of their occurrence over the study area, only a provisional value can be assigned during the field survey. A final value will need to be entered once the relative abundances of all habitat types in the study area are known.

7.3.2 Data Entry

During data entry, a well-structured field datasheet will help reduce errors arising from typographical errors and illegible field notes. Field datasheet design is discussed in Section 6.1.4, and a sample datasheet is provided in Appendix F.

Typographical errors in data entry will be minimised if the GIS specialist enters all data. The GIS specialist should have sufficient understanding of the ecological aspects of the project

Eroding/upland rivers (FW1) cascading down rocky stream bed [The Heritage Council] to detect potential errors. Any uncertainties should be clarified with the field surveyor. If the practicalities of the project dictate that the field surveyor or another individual will enter field data, the data enterer must have sufficient understanding of the cartographical issues involved in inputting and editing data.

Prior to data entry, field datasheets should be photocopied and properly filed. Datasheets should first be checked to ensure all required fields have been completed. The data enterer must be conscious of which data will be entered in which dataset, as habitats that will be entered separately into polygon, linear and point datasets will be mixed together in the same field datasheet.

Preparation of a preliminary habitat map and database prior to field survey will facilitate the data entry stage, as at this stage the datasets will be constructed and ready for completion. Use of a field computer to enter data directly in the field will greatly minimise the time required for data entry (Section 6.2.7). However, entry of some data, such as descriptive notes, may still be required.

7.4 Quality Assurance

7.4.1 Database Quality Control

Errors in a habitat database, including a GIS and any other databases that may be used, occur mainly from two sources — inherent and operational — and contribute to the reduction in quality of the data. Inherent errors occur as a result of errors that were present in the source data or documents. These are best minimised by screening such data when they are entered into the habitats databases. An estimate of confidence in external data sources should be provided to the end user. Operational errors occur through errors made during the capture and manipulation of the data, either in the field or in the office. Some examples of sources of operational errors include:

- Misidentification of habitats or species
- Errors in field mapping
- Errors during data entry such as typographical errors
- Errors in digitising

Errors can also arise due to computer storage issues when too little space is allocated to store the high-precision numbers needed to record data to a given level of accuracy.
As it is easy for errors to creep into habitat datasets, rigorous quality assurance is essential when undertaking habitat mapping. Quality assurance should be comprised of three elements:

1. Periodic inspection of subsets of data
2. Field survey rechecks
3. Systematic review of all datasets

7.4.2 Periodic Inspections

Periodic inspections entail thorough reviews of subsets of the data during the course of the habitat survey. The main purpose of these periodic inspections is to identify systematic sources of error at an early stage so that these can be remedied as quickly as possible. Examples of systematic errors that periodic reviews can discover include: routine misclassification of certain habitat types; over- or under-recording plant species; and data regularly omitted from field recording sheets or failure to record quality of desktop data sources. Periodic inspections should be conducted by an ecologist and a GIS specialist working together, as one will detect potential errors that the other may overlook.

Periodic inspections should be carried out on a regular basis when updating the GIS with information gathered during field surveying. The total proportion of the survey area to be checked should be decided at the beginning of the survey. This will depend on the size of the dataset, but should range from 5-10%. Areas to be checked should be evenly distributed geographically and among field surveyors, if multiple field teams are employed.

Periodic inspections should include the following:

- Compare habitat classification and mapping arising from the project with desktop datasets and orthophotography
- Compare preliminary habitat mapping with updated habitat mapping from data gathered in the field
- Compare field recording sheets with the GIS and any other datasets to check for data entry errors
- Run spatial queries and manipulate attribute data to:
  - Check for missing data
  - Check for voids in GIS topology
  - Check for typographical errors in habitat codes and other data
  - Identify features below a certain threshold that are likely to be digitising errors

7.4.3 Field Survey Quality

For large study areas where the field survey has been carried out by multiple teams, a proportion of the habitat survey area should be rechecked to ensure consistency in habitat classification and other aspects of data collection. Field rechecks are an important part of quality assurance, as previous research has found that there is often a high level of disagreement in habitat classification of the same area by different field ecologists (Cherrill and McClean, 1999a & b; Stevens *et al.*, 2004). Field rechecks should be carried out by field ecologists who have not previously taken part in the field surveys and who have a high level of expertise to allow them to confidently identify transitional, mosaic or otherwise difficult habitats. The project manager of a habitat survey may be able to fulfil this role. If no suitable reviewer is available within the survey team or organisation conducting the survey, consideration should be given to appointing a suitably qualified external ecologist for this task.

Example of how river valleys are often the last areas to retain biodiversity within an intensively farmed landscape [Atkins]

For habitat surveys carried out by only one field team, rechecks will not normally be necessary, assuming that the field team has suitable habitat survey expertise in the first place. However, verification in the field by an internal or external ecologist may be necessary for certain sensitive habitats or projects.

Rechecks should be conducted during the course of the field survey so that any systemic errors can be remedied before completion. The area to be rechecked will depend on the size of the total habitat survey area, but resurveying of 5% of the survey area is recommended as a rule of thumb. The locations to be rechecked should be distributed throughout the survey area insofar as possible. Spot checks of subsets of data may highlight particular habitat types, geographic areas or surveyors that deserve special attention during field recheck. However, some recheck locations should be determined randomly with respect to habitat type and surveyor so that unanticipated problems can also be identified.

Errors arising from field survey errors can be reduced by close coordination of field survey teams and training or inducting surveyors prior to commencing the field survey (Cherrill and McClean, 1999a & b; Stevens *et al.*, 2004), as recommended in Section 4.3.3.

7.4.4 Database Review

Once the habitat datasets have been entered and are in final draft format, the dataset must be systematically reviewed for errors and omissions. The main methods for quality review of the draft datasets include: 1) running spatial queries to check for data errors and omissions; and 2) the creation of thematic maps to identify errors and omissions in habitat classification and other ecological classifications. Spatial queries should be run on all data fields to identify outliers, omissions and other errors. Spatial queries should also be run on data fields in order to compile statistics. For example, querying the frequency of different habitat types will quickly identify erroneous codes; or querying the range of geographic coordinates will identify typographical or calculation errors in eastings or northings.

Quality review of the habitat datasets should include the following:

- Systematically pan through dataset and check that all polygons are closed
- Verify that all features are assigned a unique object ID
- Verify correct habitat codes by thematic mapping and queries on frequency of habitat type occurrence in the datasets
- Ensure no errors or omissions in survey method fields
- Check that all features have an up-to-date and correct easting and northing
- Verify that date of field survey is entered for all habitat features surveyed in the field, and that features not field surveyed are identified clearly
- Check that each dataset contains only the correct feature type, *i.e.* polygon dataset contains polygons, polyline dataset contains polylines and point dataset contains points
- Check and clean dataset to remove overlaps, duplicate polygons, spikes and sliver polygons

In some GIS software packages, it is possible to set up topology rules to assist with data quality. Examples of such rules are:

- ‘Must not overlap’ — requires that the interior of polygons in the feature class do not overlap
- ‘Must be covered by’ — requires that polygons of one feature class must be contained within polygons of another feature class
- ‘Must not have gaps’ — requires that there are no gaps within a single polygon or between adjacent polygons

It is advisable to make duplicate copies of the draft datasets at different stages for reference purposes. This will help identify persistent sources of error. To assist in future identification of habitats from desktop information, it may be useful to compare preliminary (desktop) habitat identifications with final, field validated habitat identification.

Where it is necessary to split a study area into smaller workable areas, it will be essential to carry out rigorous edge matching checks to ensure quality and compatibility across the study area. This is especially the case where different field teams have surveyed the adjoining tiles. In addition, there can be errors in OSi vector mapping at the point where map tile sizes change due to changes in scale (*e.g.* where a 1:2500 tile and a 1:5000 tile meet). If OSi vector mapping is used as a base map to create a GIS preliminary habitat map, errors can be introduced into the habitat dataset. To avoid these errors:

- Check polygons and polylines where they cross subdivided areas
- Check that polygons and polylines match up across tiles
- Use orthophotography to clarify where discrepancies arise
- Check that habitat classification and other data are consistent across tiles

Carrying out data cleansing prior to the creation of the habitat mapping template will eliminate many edge matching errors.

7.4.5 Reporting Data Quality

Generally, it will not be possible to provide concrete statistics on the quality and accuracy of habitat survey data due to their complex nature. However, sufficient information should be provided in the metadata and the project report so that the quality of the dataset can be evaluated by data users. Data quality should be reported under four main topics: lineage, thematic accuracy, positional accuracy and completeness.

Lineage refers to the history and processes involved in constructing the dataset. This includes overviews of the GIS and non-GIS data sources used to construct the dataset, field and desk-based methods used for data capture, and procedures for database population and management. An overview of quality assurance procedures should also be provided.

Thematic accuracy is an estimation of accuracy of information in the attribute table. The relative contribution of field survey and GIS and non-GIS data sources to habitat identification and other attributes should be evaluated. The use of the *DATA_QUAL* attribute field in the habitat database itself will greatly improve the evaluation of thematic accuracy. Quality assurance procedures should be reported and used to provide an overall estimate of thematic accuracy.

The positional accuracy of base mapping should be reported if OSi vector mapping or other mapping is used to provide a template for habitat mapping. The spatial resolution (scale) at which digitising was carried out should also be reported. The potential accuracy of GNSS units used for habitat mapping should be stated, as well as the mode of their use (*e.g.* differential v. autonomous modes). Where possible, the error estimates provided by GNSS units for individual coordinates captured, such as point locations of very small habitats or species populations, should be included in the database.

Finally, an evaluation of the completeness of the dataset should be provided, and reasons for any gaps should be stated.

7.5 Data Management

Project data in hard copy and digital formats should be carefully backed up, stored and organised in a logical, hierarchical fashion. Data storage procedures should be determined at the start of the habitat survey project. Most aspects of data storage are discussed in Section 4.5.1, but advice on handling photographs and metadata is provided in Sections 7.5.1 and 7.5.2.

7.5.1 Photographs

Photography labelling and storage are of particular importance, as individual photos can easily be dissociated from the ecological features they depict. Also, digital photos can take up a significant amount of disk space. Usually, a digital photo taken in the field will be labelled with a number by the camera, which should be recorded on the field datasheet. This provisional number should be replaced and photos labelled with the unique ID number assigned to that habitat in the GIS attribute table. Multiple photos for the same habitat can be labelled with '_1', '_2', etc. appended to the unique ID number. It is good practice to tag photographs clearly with the associated metadata upon return to the office.

The majority of photographers use the JPEG format. The advantages of JPEGs are that the images are saved in a compressed file size, numerous images can be saved on the camera, and they provide high-quality, first-use images. However, JPEGs store photographs in a lossy format, *i.e.* data are lost each time the file is modified or resaved.

TIFF files are a *lossless* format, *i.e.* data are not lost each time the file is modified or resaved. Images can be modified and resaved an endless amount of times and the quality of the image will stay unaltered. The drawback of using the TIFF format is that the size of the files is large, potentially resulting in storage difficulties on cameras, computers and other media.

RAW format files (such as NEF from Nikon or CR2 from Canon) provide high-quality images with a smaller file size. Similar to TIFF files, RAW files are a *lossless* format. One drawback to this file format is that it is not available on all cameras. Where possible, it is recommended that habitat survey photographs should be taken and saved in RAW format.

For archiving purposes, it is recommended to save RAW images to a non-proprietary format such as DNG (Digital Negative) — this is a universal format, is vendor neutral,

Photograph taken to record structural diversity associated with a scrub-dominated rocky outcrop [The Heritage Council] and holds metadata internally within the file. Where this file format is not available on the camera, TIFF files should be used in preference for their lossless quality.

Some file formats, such as XIF, allow metadata text to be associated with an image. Other supported metadata elements include IPTC Core (International Press Telecommunications Council) and EXIF (Exchangeable Image File). If hard copy photos are used, they should be labelled on the reverse with the unique habitat ID number, and other information if desired, using a permanent pen that will not bleed through or indent the image on the front.

Photos can also be associated with habitat records in the GIS or other database by using hyperlinks. Hyperlinks are file paths which link photographs to the geographic location where the photograph was taken. They can also be used to link other types of files, such as an external database containing descriptive notes, to a geographic location. However, hyperlinking is not generally recommended due to potential problems of broken links when transferring or restructuring files.

7.5.2 Metadata

As noted in Section 3.4, metadata makes information more useful to users by making it easier to understand the origin, contents and quality of datasets. All habitat survey data must be accompanied by well-structured and comprehensive metadata. Metadata concepts and standards are introduced in Section 3.4, and recommendations on producing metadata for habitat surveys are given below.

Metadata can be stored either internally (in the same file as the data), or externally (in a separate file, such as a text file, XML or database record). XML is open standard and platform independent, which enables easy exchange of information with other organisations. Both methods have advantages and disadvantages.

Internal storage allows transferring metadata together with the data they describe; thus, metadata are always at hand and can be manipulated easily and automatically updated as the associated data are modified and saved. This type of spatial metadata is produced by ESRI's ArcGIS Desktop. In ArcGIS, metadata are stored as an XML file that can be viewed in ArcCatalog according to the user's preferred XML style sheet or as a stand-alone XML file.

External storage allows for greater flexibility of software and metadata format and the ability to easily circulate metadata without associated data. As metadata are in a file that is separate from the data they describe, it is vital that they are kept in the same location as the GIS dataset.

Appendix G outlines the minimum elements required for both spatial and non-spatial metadata elements unless otherwise specified.

As noted in Section 3.4, statutory bodies should ensure that geospatial metadata for spatial datasets are compliant with the INSPIRE Directive. In order for geospatial metadata to be read directly by GIS software or INSPIRE portals, metadata must also be machine-readable (*e.g.* XML).[13] Generation of INSPIRE compliant, machine-readable metadata can be done either through GIS software (as outlined above) or via dedicated on-line editors. The free on-line metadata editor[14] developed by the INSPIRE Metadata Drafting Team facilitates creation of metadata which is compliant with the INSPIRE Implementing Rules for Metadata, as well as relevant European and international standards for geographic information (notably EN ISO 19115). It is possible to customise and add additional metadata elements to extend INSPIRE compliant metadata schemes to incorporate additional, non-INSPIRE elements, as are currently being developed by the EPA and the ISDE.

[13] *Delivery of the metadata in XML is not mandatory for INSPIRE. XML has become an industry standard for storing and transferring it across the Internet. Metadata provided in unstructured formats (*e.g.* MS Word, Excel) require further conversion before being directly readable and searchable.*

[14] *www.inspire-geoportal.eu*

7.6 Presentation of Survey Results

7.6.1 Survey Report

The form and structure of the habitat survey report will be dictated by the objectives of the habitat survey and the uses to which the information will be put. In many cases, a habitat survey will be conducted as part of a larger project, such as a research project or EIA, and the structure of habitat survey reporting should fit in with the reporting requirements of this project. For a stand-alone habitat survey, a report should be prepared that highlights the main results and interprets them in a clear, concise manner. A straightforward structure including *Introduction, Methods, Results* and *Conclusions* sections is often the best.

The *Introduction* should describe the background, context and objectives of the habitat survey and for whom it was produced. This information is important, as it will help explain

Photograph taken to record notable point feature, in this case, rich lichen coverage on outcropping rocks [The Heritage Council] the survey methodology and any constraints or difficulties that were encountered. The reasons for undertaking the habitat survey and the benefits to be gained from the results should be emphasised. The survey area should be described briefly and presented in a map. The reasons for selecting the area should be discussed.

The *Methods* section should clearly outline the habitat survey procedure at the planning, desktop survey, field survey and post-survey stages. This is particularly important for large-scale surveys that may take a number of years to complete and may involve different personnel or project teams. Any constraints that have influenced the methodology should be clearly explained, as should any departures from this Guidance. Sources of desktop information, including consultees, should be outlined and details provided in a Literature Cited section or Appendix, if appropriate. GIS software and methods used for preliminary habitat mapping and other data acquisition should be described clearly. Field survey methodology should be discussed, including survey dates, number of field teams and survey area division, and data collected in the field. The level of field survey and the level of reliance on remote methods for habitat mapping should be detailed. A copy of the field datasheet should be presented in an Appendix. Post-field survey procedures should be outlined, including data entry and quality assurance procedures. If any statistical analysis methods are used, they must be summarised and referenced. Approaches used to evaluate the conservation value of habitats and activities that may influence conservation status should be clearly defined.

The *Results* section should provide a concise description of the main findings of the habitat survey. The structure and contents of the habitat survey database should be outlined. A presentation of summary statistics, such as total area or length of habitat types, will provide a good overview of the study area. The typical composition, structure and other characteristics of the main habitat types should be described briefly. Somewhat more attention should be paid to describing habitats and habitat complexes of biodiversity significance. The remainder of the Results section will be dictated by the survey objectives and other requirements of the habitat survey commissioner, but may include more detailed consideration of the conservation value of habitats and localities, identifying key biodiversity threats or providing more detail on the plant and animal species present in the study area. In some cases, a separate Discussion section may be warranted to evaluate survey results. Otherwise, any interpretation required can be combined in the Results section or in the Conclusions.

The *Conclusions* section should highlight the main findings of the habitat survey and explain their significance. A critical assessment of the strengths and weaknesses of the habitat survey itself should be outlined, including any recommendations for the conduct of future habitat surveys. Where appropriate, recommendations for conservation, management or further research should be included.

In the preparation of the survey report, confidentiality issues must be considered in the context of how widely the report will be circulated. Confidentiality of private individuals and sensitive species is discussed in Section 6.1.2. These issues must also be balanced with obligations regarding the availability of data gathered with public funding.

7.6.2 Habitat Maps

Map Design

Map design is a creative process during which the cartographer or map-maker tries to convey the message of the map's objective. Users can interpret data incorrectly due to the visual presentation of results. If colours and shading are inappropriate, or if the map is too crowded, this will cause errors in the interpretation of the data. For a map to be understood, several key elements should be included. A map should have one primary message that is instantly clear to people who see it. Only essential information should be shown on the map.

Once the data have been digitised and attributed in a standardised manner, map display options are very flexible. However, all maps should include the following elements:

- A scale bar
- A map body or data frame
- A grid, spatial reference or an index/overview map
- Title, figure number and version number
- Direction indicator
- Legend
- Map metadata (*e.g.* coordinate reference system, OSi licence number)
- Neatlines

Colour Coding

It is strongly recommended that the final habitat map should be colour coded. The use of colour and fill patterns allow the often complex spatial arrangement of habitats to be presented clearly, and enable a rapid visual assessment of their abundance and distribution (JNCC, 2007). Natura Environmental Consultants (2002, 2005) provided a colour-coding scheme for *A Guide to Habitats* habitat types in the draft *Habitat Survey Guidelines* prepared for the Heritage Council.

A single, uniform scheme for coding *A Guide to Habitats* habitat types by colour and fill patterns would be desirable to facilitate interpretation and interoperability of different habitat maps. However, a scheme that would be suitable for every habitat map is not possible, due to the large number of habitats defined under level 3 of *A Guide to Habitats* classification, in addition to the potential for mosaics of many of these habitat types. A single, uniform scheme would require such a diversity of colours and fills that clear differentiation could not be guaranteed between all combinations of adjacent habitats that are likely to occur together. Instead, this Guidance outlines below some general principles to assist with colour choice and fill patterns, which should be considered when preparing habitat maps.

In general, the choice of colour coding and palette styles to be used should be dictated by the objectives of the project. The habitat map should highlight the main message to be conveyed. Factors including scale of presentation, frequency of habitat types present within an area, habitats that are located near each other, and presentation of background mapping or other features should be taken into account.

The more common and less ecologically important habitats should be presented using pale colours and simple patterns, and less common or more important habitats should be presented more strongly for emphasis. This is particularly important for large-scale maps where busy patterns and garish colours can obscure important features. Habitats that occur adjacent to each other should clearly contrast. Fill patterns should be kept simple, as patterns that are too busy will obscure the message the map is trying to communicate. Finally, a habitat map should be attractive to the viewer.

Colours on a map should intuitively reflect the feature which they represent. This is reflected in the base colours used for depicting habitats under the JNCC (2007) Phase 1 habitat classification and in the colour scheme produced to accompany the draft *Habitat Survey Guidelines* prepared by Natura Environmental Consultants for the Heritage Council (2002, 2005). In line with these schemes, the following colours should be used, where possible, in the interest of producing easily interpretable maps:

- Blue to represent freshwater features
- Green to represent woodland and scrub
- Red to represent rocky or disturbed areas
- Yellow/orange to represent grasslands
- Grey to represent cultivated and built land
- Brown to represent heath and bracken
- Purple to represent peatlands

In particular, large-scale habitat maps should use this colour palette for consistency in presentation and interpretation. This will allow maps from different habitat mapping projects to be compared quickly and easily. However, where this colour palette inhibits interpretation, modifications should be made which are appropriate to the scale of the map.

Opaque schemes can be constructed that use a solid base colour in combination with patterns, such as stripes or checkerboards in contrasting colours. An opaque colour coding scheme provides many more contrasting combinations than a translucent scheme, and is thus useful for large-scale habitat mapping projects with a large number of habitats present. The chief disadvantage is that such a habitat map cannot be overlaid on base mapping.

A *translucent scheme* is one where coloured fill patterns, such as stripes or dots, overlay a transparent background. A translucent scheme is useful when undertaking small-scale, site-based habitat mapping projects, as it allows the habitat map to be overlaid over a base map. As a translucent scheme inherently provides less contrast between habitat types, such a scheme is most suitable where fewer habitat types are present.

Depiction of linear habitats should follow similar guidance to those discussed above. In general, simple lines are preferable to more complex line styles. The scale at which the map is being presented will influence the thickness or weight at which linear data should be presented. At larger scales, thinner line styles should usually be used, as greater densities of linear habitats can dominate large-scale maps.

Point data should be presented using simple symbols at a size that is appropriate to the scale of the map. Point habitats, such as springs, should follow the general colour guidance outlined above. Mapping point data other than habitats may sometimes be required, such as locations of particular species, animal signs or conservation threats. Common methods of mapping point data include:

- Each attribute type is given a different symbol class – colour, shape orientation or lettering
- Each attribute is given a hierarchy of symbols or lettering using colour and size
- Each attribute type is given a graduated symbol using colour or size

Depending on the specifications of the project and the type of features to be shown, symbol colours and styles should be chosen appropriately. For example, if the map includes a lot of point data, symbols should be kept simple, their size relatively small, and colours plain but distinguishable to the map reader. For maps with fewer points, symbols should be more colourful and larger to ensure visibility.

It should be noted that colours viewed on-screen may sometimes appear different in print due to differences in interpretation between the printer and computer monitor. Converting habitat maps to PDF or other file formats may also alter colours. Also, different printers may print the same colours in slightly different shades. When preparing habitat maps for viewing in print, it is advisable to inspect the results of trial print runs prior to finalising colour and fill pattern schemes.

Finally, it should be noted that the colour-coding scheme(s) chosen for map presentation are the final step in a habitat mapping project, and that these are easily changed at a later date. The critical element for producing high-quality, interoperable habitat mapping data is the design of the data structure.

8
USES OF HABITAT SURVEY DATA

8.1 Overview

The uses to which habitat survey data are put will be dictated by the nature of the specific project. Habitat data can be evaluated and impacts assessed as part of an Ecological Impact Assessment. Alternatively, data can be used to inform decision-making such as strategic planning decisions, assist in the identification of important biodiversity areas, or determine the need for further ecological research. The type of data analysis, evaluation and presentation depend on the objectives of the habitat survey. Therefore, detailed advice on numerical analyses of habitat survey data is outside the scope of this Guidance.

This chapter provides some general information on:
- Basic spatial analysis of GIS data
- Evaluating the conservation value of habitats and conservation threats
- Limitations of habitat survey data
- Quantitative vegetation description and analysis

8.2 Spatial Analysis

GIS software can perform a variety of different kinds of analysis of geographic information. Spatial analysis, a process whereby raw data are turned into useful information to meet research aims or facilitate more effective decision-making, can be used to reveal patterns in data that were not previously recognised. The type of spatial analysis performed in a habitat mapping project will depend on project objectives; it will also be limited by the information gathered as part of the survey, its accuracy, and the structure of the GIS database. Most GIS software packages supply specific tools with which to interrogate datasets, although the name allocated to the tool may differ from package to package. A brief description of available analyses is given in Box 8.

Cliffs of Moher, Co. Clare, which supports notable plant assemblages and breeding seabirds [The Heritage Council]

Box 8. GIS Spatial Analysis

QUERIES
Boolean search is the ability to search an attribute table to find objects satisfying specified criteria.
Search by attribute is the ability to search the database for features with specific attributes. This function also permits the suppression of unneeded information.
Gap analysis is the ability to automatically delete small sliver polygons which result from errors during digitisation.
Join is a procedure that attaches values from an attribute table to another attribute table based on a common or relational feature. The join function can be used to join two attribute tables for specific data analysis.
MEASUREMENTS
Measure is the ability to count the number of objects in a feature class or measure distances along a specified line.
Area calculation is a technique that can calculate the area of a polygon.
TRANSFORMATIONS
Reclassification is the modification of a set of attributes based on a set of user-specified rules. Reclassification might be used during a habitat mapping project to reclassify habitats from level 3 to level 2 of the *Guide to Habitats* classification.
Buffering involves the creation of a buffer at a specified distance around a point, polyline or polygon feature. The buffer can be queried to determine whether features are within or outside the defined buffer. Buffers also help demonstrate relationships between themes.
Aggregating attribute fields is used to merge boundaries between adjacent polygons with identical attributes to form a larger polygon. This function can also be used for polylines.
Overlay is used to determine where two polygons overlap and to delineate the overlapping area as a new polygon. Overlay is useful when exploring relationships and associations in the data.
Intersect is the ability to overlay one set of polygons onto another to form a topological intersection of the two. A new polygon is created to show the overlapping area.
Nearest neighbour is the ability to identify points, polylines or polygons that are nearest to other points, polylines or polygons.
Connectivity analysis is the ability to identify where points and polygons are connected to other points or polygons by linear features.
Spatial interpolation is a process in which the investigator attempts to make a reasonable estimate of the value of a continuous field at places where the field has not actually been measured. The interpolation is based on field values of nearby objects.
Summary Statistics
One of the most useful forms of analysis that can be carried out as part of a habitat mapping survey is the measurement of the extent and percentage cover of each of the types of habitats in the area covered by the survey. These data can then be used to inform decision-making. In a GIS, the statistics tools assist in quantifying relationships while taking into account spatial location. Other summary statistics available include minima, maxima, averages, frequencies and variance statistics.

8.3 Habitat Evaluation

8.3.1 Conservation Value

Evaluating the conservation value of habitats, complexes of habitats or sites is an important application of habitat survey data. The evaluation should be based on balancing a number of criteria that contribute to overall conservation value and should consider a wide range of plant and animal taxonomic groups. Due to the complexity of this task, assessing the conservation value of habitats or sites can be difficult. No single evaluation scheme can be rigorously or consistently applied to give a simple conservation rating for all habitats.

It is outside the scope of this Guidance to develop or propose a methodology or framework to assess conservation value. However, an outline is provided here of some of the criteria to be considered, as well as some of the evaluation schemes currently applied. This Guidance does not endorse any of these schemes for general-purpose evaluation of habitats, as this is outside the scope this Guidance. The selection of an evaluation system (or development of a new one) should be carefully considered in the context of the habitat survey objectives.

The NPWS survey manual for ASIs (Lockhart *et al*., 1993) discusses the use of the Ratcliffe criteria in the evaluation of conservation sites, including former ASIs, for consideration as pNHAs in Ireland. Although ASIs were formerly rated as being of international, national, regional or local importance, as do some of the schemes discussed below, ranking of sites is not proposed in the NHA manual. The criteria used to evaluate potential NHAs include naturalness, non-recreatibility, potential value, typicality, size, diversity, rarity of species and habitats, proximity to other valuable sites, viability, recorded history and research, potential educational value, practical management considerations and intrinsic appeal. The application of each of these criteria is discussed extensively. Naturalness, size and diversity are generally considered more important criteria than the remainder for most habitats. Rarity of species overrides most other criteria in many cases, according to the survey manual, and can justify designation solely or mainly on the basis of rare species.

The IEEM provides useful advice on assessing the conservation importance of habitats and other ecological features for EcIA (IEEM, 2006a). However, the IEEM guidelines do not provide a scheme defining how habitats should be assigned to different levels of value, saying: *'such definitions proved to be unworkable in that they cannot accommodate all of the factors that should influence the definition of value'*. Some of their recommendations include using a geographically scaled frame of reference and separating legal protection from biodiversity value.

Several structured systems for ranking the conservation value of habitats have been used in Ireland. Some are designed for specialist purposes and others are tailored for use in particular habitats. Some of the more commonly used are outlined below.

Natura 2000 sites (SACs and SPAs) are evaluated according to criteria outlined in Annex III of the Habitats Directive. These criteria are representivity, relative surface (size) and conservation status, the latter of which includes as sub-criteria the degree of conservation of structure, degree of conservation of function, and restoration potential. The criteria are evaluated on simple three-point ranking scales and combined to produce a global assessment for each Natura 2000 site. The results of this assessment are reported on the Natura 2000 Standard Data Forms produced for each site by NPWS.

Box 9. Ratcliffe (1977) Criteria for Evaluating Conservation Sites

Diversity: Sites with a greater diversity of species and habitat structure are of greater value than low diversity sites, as a general rule. Diversity must take into account both richness – *e.g.* number of species – and evenness – *e.g.* their relative distribution. As a general rule, estimates of species diversity should be limited to native and long-naturalised species. (For vascular plants, long-naturalised species are those thought to have been introduced to Ireland prior to AD 1600 and are known as archaeophytes.) As with size, diversity comparisons must only be made between similar habitats, as some are naturally species-poor (*e.g.* oak-birch-holly woodland) and others are naturally more diverse (*e.g.* oak-ash-hazel woodland).
Fragility: The more sensitive a habitat is to human interference – including direct and indirect disturbances, ecosystem stresses, invasive species and climate change – the more valuable it is. This reflects the need to afford more protection to sites that can lose species or ecosystem function more quickly than more robust sites.
Naturalness: In general, sites that exhibit less human influence are of greater conservation value than those that are highly modified. However, exceptions include sites that 'score' highly under another criterion. For example, quarries are entirely artificial habitats, but some sites have high species diversity and support rare plants.
Non-recreatability: A habitat that is more difficult or impossible to recreate is of greater conservation importance than one that is more readily created. This reflects the need to afford more protection to sites that are less resilient than to those that can recover quickly from disturbance or stress. Non-recreatable habitats tend to be those dependent on specific geological or hydrological conditions that are difficult to replace or simulate once lost. Examples include raised bogs, alkaline fens, turloughs and limestone pavement.
Position in the ecological unit: This criterion refers to the relationship of a site to nearby areas of conservation value. Proximity to other sites of nature conservation importance enhances the ability of a site to act as a source and sink for species moving between the two sites and improves the connectivity of the wider landscape.
Rarity: Rare habitats and species are of higher conservation interest than common ones. The most important habitats and species are those that are rare internationally, *i.e.* globally or in Europe. Next most important are those that are nationally rare, followed by regionally rare and locally rare.
Size: Larger sites are of higher conservation value than smaller sites, as larger sites are less subject to edge effects and have a lower risk of loss of species due to random events. Larger sites are more likely to support a greater diversity of species and microhabitats. Assessing the size of the site must take into account the type of habitat involved, as small examples of some habitat types may be viable over the long term, whereas others require a larger area to maintain ecological integrity.
Typicalness: All things being equal, a habitat that contains most or all of the characteristic features typical of the habitat type is of greater value than an atypical example. (However, atypical sites may also be valuable due to higher diversity or because they represent a rare ecotype.) As it is difficult for a single site to contain all the features of a given habitat type, a good 'typical' site may be one that encompasses the range of habitat variation within the region in which it is located.

The National Roads Authority (NRA) guidelines for EcIA of national roads projects include a system for evaluating sites, habitats and species populations on a five-point geographic scale of importance (NRA, 2009). The rankings are: international importance, national importance, county importance, local importance (higher value) and local importance (lower value). This ranking scale takes into account criteria such as rarity, naturalness and position in the ecological unit. Statutory designation is explicitly included as a valuation criterion.

Prior to the NRA's publication of the original scheme for evaluating the ecological importance of habitats in 2006, there was no widely accepted scheme in Ireland.

However, a number of schemes were in circulation, including a scheme developed by Gittings (RPS, 2001). This is based on a six-point geographic scale similar to that of the NRA (2006) scheme. It differs, however, in including a category of sites of county importance, a category since added to the revised NRA scheme (NRA, 2009). 'Local' scale was explicitly defined as roughly equivalent to one 10 km square, but this could be adapted to fit the spatial and ecological characteristics of the area of interest. Evaluation criteria include rarity, naturalness, typicalness and diversity in line with the Ratcliffe criteria. This was further refined in O'Donoghue *et al.* (2009).

Scoring systems for evaluating conservation value are an alternative method. In these systems, points are scored under a number of criteria, and a final conservation score is then produced for each site. BEC Consultants have developed two scoring systems for sites in the context of the National Native Woodland Survey (Perrin *et al.*, 2008a) and grassland surveys of Roscommon and Offaly (Martin *et al.*, 2007). Criteria used in these studies include: rarity, size, connectivity to other habitats, age, built heritage features, and diversity of species, habitats and structure. A similar scoring scheme has been applied by Foss and Crushell (2007, 2008) in ranking the importance of fens, with categories broadly based on the criteria discussed by Lockhart *et al.* (1993).

These scoring systems are habitat and project specific, which can be seen as an advantage as they are better tailored to meet particular characteristics and objectives. However, two disadvantages are that different habitat types cannot be easily compared, and new scoring systems must be developed for different habitat types or projects. Scoring systems can allow a more precise ranking of sites; however, they must be carefully balanced so that high or low scores in one or a few criteria do not bias the results.

Eroding blanket bog (PB5), Co. Donegal [Atkins]

Regardless of what conservation evaluation system is used, the interactions of the habitat with adjacent habitats and the wider landscape should be considered when evaluating habitats. Insofar as possible, conservation value of habitats and sites should be done in the field. However, evaluations should be reviewed at the end of the survey so that they can be informed by the overall quality and abundance of habitats in the survey area and by research on species distributions and other information. Where a habitat survey takes place over a number of years, the conservation values of habitats or sites assigned in previous years should be reviewed as additional data that provide a better understanding of the status of different habitat types within the survey area become available.

8.3.2 Condition and Threats

Information on the ecological condition of habitats and sites or factors that threaten their ecological integrity is useful for strategic or site-level conservation planning. It is outside the scope of this Guidance to do more than provide information on several different approaches to assessing site condition that may be suitable, depending on the objectives of the habitat survey.

A detailed protocol for the assessment and monitoring of habitats of European conservation interest exists under Article 17 of the Habitats Directive (European Commission, 2006). This protocol was used by NPWS to produce a review of the conservation status of annexed habitats and species in Ireland (NPWS, 2008). Under this system, range, area, structure and function, and prospects of habitats are assessed as being of Good, Poor or Bad status. The precise evaluation criteria and methods for assessment vary according to habitat type, and further information can be obtained from NPWS.

The JNCC has a series of guidelines for monitoring the condition of the UK's Biodiversity Action Plan (BAP) habitats. These contain guidance on developing measures for condition monitoring based on the use of indicators of good composition, structure and function. For example, suggested indicators for monitoring lowland fens (including alkaline fens) include vegetation cover, litter cover and presence of positive and negative indicator species that reflect hydrological, grazing and nutrient conditions (JNCC, 2004). These indicators are assessed at a series of monitoring points or along a transect, and an evaluation is made as to whether a site is in favourable or unfavourable condition based on meeting target criteria. This type of methodology requires the development of habitat type specific criteria and may be useful for surveys focusing on particular habitat types. It is likely to be too detailed and time-consuming for general habitat surveys.

An alternative approach to assessing habitat condition is to evaluate the potential threats that negatively impact on habitats or are likely to do so in the future. Assessment of conservation threats is best assessed through repeat surveys or monitoring, and any threats identified on the basis of a single visit should be regarded as potential. Particular threats can be listed to provide more detailed information on management needs. When recording potential threats, it is advisable to use a defined list of threat classes or codes for consistency. For a more general habitat survey, the recommended option is to use the codes used in standard Natura 2000 data forms for assessing the impacts and activities that influence the conservation status of SACs and SPAs. The list of codes adapted for Ireland and used by NPWS is provided in Appendix E.

Different threat types can be weighted and summed to produce an overall threat index. This can be a useful way of highlighting sites that can be improved with better management. An example of this approach applied to rare species is used in the Red Data Book for vascular plants (Curtis and McGough, 1988), and similar approaches have been devised for habitats (Martin *et al.*, 2007; Perrin *et al.*, 2008a). The chief drawback of this approach is that the weights used for different threat factors must be carefully balanced to ensure that one type or group of threats does not excessively influence the index.

Woodland ride which can provide foraging habitat for bats [The Heritage Council]

8.3.3 Identifying Sites of Conservation Interest

It is outside the scope of this Guidance to provide detailed advice on identifying sites of conservation interest, or on the consultation or public participation exercises that should be conducted when doing so; however, some approaches and criteria that should be considered are briefly discussed. Habitat survey data are often used to identify sites of conservation interest for management or safeguarding at local or county levels. For example, an objective of many local authority BAPs is the identification of areas of local biodiversity importance. Assuming that the conservation value of habitats or sites has been evaluated, this can be relatively straightforward. If a geographically ranked evaluation system is used, then habitats of significant conservation importance at the county level or other scale of interest can be identified. If undesignated sites are discovered that the ecologist considers are of conservation importance at the international or national scale, NPWS should be informed.

Identification of ecological corridors or stepping stones is sometimes a requirement of habitat survey projects. Corridors or stepping stones are habitat patches that may not necessarily be of high conservation value themselves, but serve to maintain ecological connectivity in the landscape. An ecological corridor should permit the movement of fauna and flora between areas of high conservation interest or through areas that have little ability to support these species. Corridors are not necessarily linear features, and not all linear features can function well as ecological corridors. The ability of a semi-natural habitat to act as a corridor must be evaluated in terms of its permeability for the species that will use it. The permeability of a habitat will depend on its suitability for a given species and on its distribution or continuity. For example, a field of wet grassland between two native woodlands will not act as a corridor for some woodland flora, such as wood anemone *(Anemone nemorosa)*; however, a commercial sycamore plantation may suffice. Species with poor powers of dispersal, such as some vascular plants and some invertebrates, require more or less continuous corridor habitats, whereas other species, such as birds or mammals, can cross areas of less suitable habitat to reach patches of better habitat. Such species will be able to avail of stepping stone habitats, whereas the first group will not.

8.4 Beyond Habitat Survey

8.4.1 Limitations of Habitat Survey Data

Although habitat survey and mapping projects can provide useful baseline information on the ecology of an area, habitat surveys are not suited to answering some types of questions. In comparison with other ecological survey methodologies, habitat surveys aim to collect basic information quickly over a relatively large area. They concentrate mainly on vegetation and any species recording is largely non-quantitative. Due to these characteristics, habitat surveys can only provide limited or preliminary data on:

- Rare or cryptic species
- Fauna
- Comprehensive botanical inventories
- Quantitative analysis of vegetation composition and structure
- Abiotic environmental conditions
- Ecological change due to management or other factors

A habitat survey is a single snapshot in time, and so can provide only limited information on environmental change. However, repeated habitat surveys can be part of a programme of ecological monitoring.

The information collected by a habitat mapping project depends on the habitat classification scheme(s) used. Translating habitat classifications according to the *Guide to Habitats* to other schemes can never be exact. The same caution applies to updates of classification schemes. If more robust information on the vegetation of a site that is independent of any one classification is desired, then more detailed methods of plant community recording will be required.

If more detailed ecological information is required by the objectives of a particular project, additional studies should be carried out. These may be carried out at the same time as a habitat survey or form a separate programme of work, depending on expertise of the field ecologists, seasonal constraints and practicality. Detailed advice on surveying methods beyond habitat survey are beyond the scope of this Guidance. However, some aspects of quantitative vegetation analysis are discussed in Section 8.4.2.

8.4.2 Quantitative Vegetation Analysis

The JNCC framework of habitat survey distinguishes between Phase 1 survey – a habitat survey, classification and mapping exercise similar to that described in this Guidance – and Phase 2 survey, which includes recording of vegetation in relevés and classification according to the British NVC. Where questions remain that simple habitat survey cannot address, a more quantitative approach to vegetation analysis is required. This involves recording the relative abundances of plant species in a series of sample units, as well as additional information on vegetation structure and environmental factors. The resulting data can be analysed numerically and compared with previous research in a more rigorous fashion. Vegetation survey and analysis require much more expertise in vegetation ecology than does habitat surveying.

Quantitative vegetation analysis is required for many ecological research purposes. Other situations in which more detailed vegetation studies should be considered include:

- Difficult-to-classify habitats potentially of conservation importance
- Long or short-term conservation monitoring projects
- Descriptions of habitats of high importance that may be subject to significant impacts due to a particular plan or project
- Descriptions of new or regional variants of vegetation types
- Quantitative data on species richness, evenness, frequency or distribution

Vegetation is recorded in one or more sample units known as plots, quadrats or relevés. The most appropriate plot size in which to record vegetation depends on the objectives of the study and the habitat. As a rule of thumb, the larger the plants and the more heterogeneous the environment, the larger the plot should be. Kent and Coker (1992) provide advice on determining what quadrat sizes to use in different habitat types. Other types of sampling units, such as transects, can be used to record vegetation, depending on the survey objectives.

The relative abundance of different plant species, including bryophytes, should be recorded in quadrats. Recording species presence or using the DAFOR scale is generally inadequate. Recording relative abundance can be done to the nearest 5% or 10% cover. It may be easier or more meaningful to record abundance using an ordinal scale with a number of classes of varying breadth. In Ireland, the most commonly used of these is the Domin scale (Box 10). The Braun-Blanquet scale is also sometimes used.

Aspects of vegetation structure in quadrats should also be recorded. Information on vegetation structure can indicate levels of stress or disturbance, recruitment history, and prospects for regeneration. Vegetation structure data can include mean or maximum height of vegetation, diameter of trees, density of individuals, abundance of litter or dead wood, and cover of bare soil, rock or water.

A wide variety of abiotic information can be collected from vegetation plots. Perhaps the most useful are topographic variables, such as elevation and site aspect, and soil variables, such as soil type, depth, texture, organic content, pH, moisture and fertility. Alternatively, information on abiotic conditions can be deduced from the range of conditions favoured by the plant species present. Ellenberg *et al.* (1991) defined several indicator scales for environmental variables, such as light, soil moisture, pH and fertility, and assigned vascular plant species in Germany with values for these scales. Ellenberg values have been adapted for the flora and environmental conditions in Ireland and Britain, most recently in *PLANTATT* (Hill *et al.*, 2004).

Box 10. Domin Cover – Abundance Scale

The Domin scale is an ordinal scale in that the values of the scale indicate changes in abundance, but the differences between different levels of the scale are non-linear. Several versions of Domin exist; the one presented below is from Kent and Coker (1992). The Domin scale ratings can be used directly in non-parametric methods of data analysis, including NMS ordination, although any rating of '+' will have to be converted to a numeric value. Alternatively, Domin scale rankings can be transformed into percentage cover values for use in a wider range of numerical analysis techniques. The chief drawback of the Domin scale is that cover and abundance are conflated for ranks +, 1 and 2. Assessing the number of individuals of clonal species can be difficult or meaningless. Also, a few individuals of larger species can exceed the cover of many individuals of smaller species. These problems have led to many ad hoc modifications of the Domin scale.

10	Cover 91-100%
9	Cover 76-90%
8	Cover 51-75%
7	Cover 34-50%
6	Cover 26-33%
5	Cover 11-25%
4	Cover 5-10%
3	Cover 1-4%
2	Cover < 1% and several individuals
1	Cover < 1% and 1-2 individuals
+	Cover < 1% and a single individual

Once plant community data have been collected, they can be compared with previous research to draw conclusions about the ecology and conservation importance of the vegetation being studied. Numerical analysis of vegetation data is often necessary. This can include the derivation of summary statistics, such as means, measures of variation, species richness and diversity indices. Magurran (2004) provides a good overview of the use of diversity indices and other methods for measuring biodiversity. The quality of any data analysis depends on the quality of data collected in the field.

The main trends of variation in vegetation data are best seen through ordination. Ordination techniques allow the main patterns in species variation and the main factors driving species variation to be summarised. It is a multivariate data analysis technique whereby the complex variation in species abundances in a number of relevés is simplified into a two or three-dimensional graph. Two main methods of ordination are indirect ordination and direct ordination. In indirect ordination, only the species data are used to produce the final solution in reduced space. Environmental variables can be overlaid passively to help with interpretation. Commonly used ordination methods include principal components analysis (PCA), correspondence analysis (CA) and non-metric multidimensional scaling (NMS). Each of these methods has advantages and disadvantages. The use of NMS for ecological data is increasing in popularity as it is robust, can be used with ordinal data, and performs well in discovering complex ecological gradients. Direct ordination uses environmental data to predict species data in the same ordination diagram in a manner analogous to regression analysis. The most commonly used direct ordination method is canonical correspondence analysis (CCA).

An allied technique is the clustering of species data into a small number of classes. This can be useful for developing new habitat classifications or ad hoc vegetation types for later investigation. Cluster analysis has been used to develop objective vegetation classifications, as discussed in Section 8.4.2. As with ordination, there are numerous techniques for cluster analysis. The NVC is based on a TWINSPAN (two-way indicator species analysis) clustering of relevé data; however, more recent research advises against the use of TWINSPAN (Legendre and Legendre, 1998). Perrin *et al.* (2008a, b) used a hierarchical clustering technique coupled with indicator species analysis (Dufrêne and Legendre, 1997) to develop an objective two-level classification of Irish woodlands.

More detailed advice on vegetation description and analysis is beyond the scope of this Guidance. There are a number of books available that provide guidance for carrying out more detailed field surveys of plant communities. To name only two, Kent and Coker (1992) is a standard text, whereas a more recent work is Hill *et al.* (2005). A number of books and papers also review and discuss methods of numerical analysis of ecological data and a diversity of software packages for carrying them out. Two potentially useful references are McCune and Grace (2002) and the more technical Legendre and Legendre (1998).

As a final note, ecologists are encouraged to submit relevé records to the National Biodiversity Data Centre for inclusion in the National Vegetation Database. A sample relevé card detailing the minimum data elements required for a valid record can be obtained from the National Biodiversity Data Centre website. Records should only be submitted with the agreement of the data owner or commissioner.

Yellow rattle, a hemi-parasitic species characteristic of species-rich grassland [The Heritage Council]

LITERATURE CITED

Bond, K.G.M. and Gittings, T. (2008). *Database of Irish Lepidoptera. 1- Macrohabitats, Microsites and Traits of Noctuidae and Butterflies.* Irish Wildlife Manual 35. National Parks and Wildlife Service, Dublin.

Botanical Society of the British Isles (BSBI) (2009). *Axiophytes.* http://www.bsbi.org.uk/html/axiophytes.html. Accessed 04/09/09.

Braun-Blanquet, J. and Tüxen, R. (1952). Irische Pflanzengesellschaften. *Veröff. Geob. Inst. Rübel 25: 224-421.*

Buczacki, S. (2007). *Garden Natural History.* New Naturalist Series No. 102. Harper Collins.

Burrough, P.A. and McDonnell, R.A. (1998). *Principles of Geographical Information Systems.* Oxford University Press, New York.

Burt-Smith, G. and O'Reilly, C. (2009). Building on bog? Some issues for ecologists evaluating development proposals impacting on a European protected habitat. *In Practice* 63: 13-16.

Campbell J. B. (2002). *Introduction to Remote Sensing.* Guildford Press, New York.

Chapman, A.D. and Grafton, O. (2008) *Guide to Best Practices for Generalising Primary Species-Occurrence Data.* Global Biodiversity Information Facility, Copenhagen. http://www2.gbif.org/BPsensitivedata.pdf. Accessed 12/2/10.

Cherrill, A. and McClean, C. (1999a). Between-observer variation in the application of a standard method of habitat mapping by environmental consultants in the UK. J*ournal of Applied Ecology* 36: 989-1008.

Cherrill, A. and McClean, C. (1999b). The reliability of 'Phase 1' habitat mapping in the UK: the extent and types of observer bias. *Landscape and Urban Planning* 45: 131-143.

Comhairle na Tuaithe (2005). *Access Parameters and Countryside Code.* Department of Community, Rural and Gaeltacht Affairs, Dublin. http://www.pobail.ie/en/RuralDevelopment/ComhairlenaTuaithe. Accessed 04/09/09.

Connor, D.W., Brazier, D.P., Hill, T.O., and Northen, K.O. (1997). Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Vol. 1. Littoral biotopes. Version 97.06. Joint Nature Conservation Committee Report, No. 229.

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F., and Sanderson, W.G. (1997). Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Vol. 2. Sublittoral biotopes. Version 97.06. Joint Nature Conservation Committee Report, No. 230.

Crick, H.Q.P. (1992). A bird-habitat coding system for use in Britain and Ireland incorporating aspects of land-management and human activity. *Bird Study* 39: 1-12.

Curran, P. (1989). *Principles of Remote Sensing.* Longman, London.

Curtis, T.G.F. and McGough, H.N. (1988). *The Irish Red Data Book: 1 Vascular Plants.* Wildlife Service Ireland, The Stationery Office, Dublin.

Davies, B. R., J. Biggs, P. J. Williams, J. T. Lee and S.Thompson, (2007). A comparison of the catchment sizes of rivers, streams, ponds, ditches and lakes: implications for protecting aquatic biodiversity in an agricultural landscape. *Hydrobiologia* 597: 7-17

Davis, B .E. (1996). *GIS: a Visual Approach.* OnWord Press, Albany.

Department of the Environment (1987). *Handling Geographic Information.* Report of the Committee of Enquiry chaired by Lord Chorley.

Devillers, P. and Devillers-Terschuren, J. (1993). *A Classification of Palaearctic Habitats.* Council of Europe, Strasbourg.

Drafting Team Metadata and European Commission Joint Research Centre (DTM and ECJRC) (2009). *INSPIRE Metadata Implementing Rules: Technical Guidelines Based on EN ISO 19115 and EN ISO 19119.* v. 1.1. European Commission Joint Research Centre. http://www.inspire-geoportal.eu/

Dublin Core Metadata Initiative (2010). *Dublin Core Metadata Initiative.* http://dublincore.org. Accessed 20/01/10.

Dufrêne, M. & Legendre, P. (1997). Species assemblages and indicator species: the need for a flexible asymmetric approach. *Ecological Monographs*, **67**, 345-366.

Dunnett, N. and Hitchmough, J.D. (2004). *The Dynamic Landscape: Design Ecology and Management of Naturalistic Urban Planting.* SPON, London.

Ellenberg, H., Weber, H.E., Düll, R., Wirth, V., Werner, W. and Paulissen, D. (1991). Zeigerwerte von Pflanzen in Mitteleuropa. *Scripta Geobotanica* 18: 1-248.

English Heritage (2003) *Where on Earth Are We? The Global Positioning System (GPS) in Archaeological Field Survey.* English Heritage, London. http://www.english-heritage.org.uk/upload/pdf/where_on_earth_are_we.pdf?1242210448. Accessed 04/09/09.

Environment Agency United Kingdom (2003). *River Habitat Survey in Britain and Ireland.* Field Survey Guidance Manual.

Environmental Protection Agency (EPA) (2008). *CORINE Land Cover Mapping.* http://www.epa.ie/whatwedo/assessment/land/corine/. Accessed 04/09/09.

European Commission (1991). *CORINE Biotopes Manual: Habitats of the European Community.* European Commission, DG Environment.

European Commission (2006). *Assessment, Monitoring and Reporting Under Article 17 of the Habitats Directive: Explanatory Notes and Guidelines.* European Commission, DG Environment.
http://circa.europa.eu/Public/irc/env/monnat/library?l=/habitats_reporting/reporting_2001-2007/guidlines_reporting&vm=detailed&sb=Title. Accessed 04/09/09.

European Commission (2007). *Interpretation Manual of European Union Habitats.* EUR 27. European Commission, DG Environment.

Fealy, R., Loftus, M. and Meehan, R. (2006). *EPA Soil and Subsoil Mapping Project: Summary Methodology Description for Subsoils, Land Cover, Habitat and Soils Mapping/Modelling. Version 1.2. Report prepared for EPA.*

Forest Service (2005). *Native Woodland Manual.* Forest Service, Johnstown Castle.

Forest Service (2009). *Forest Cover Datasets.* http://www.agriculture.gov.ie/forestservice/forestservicegeneralinformation/abouttheforestservice/forestcoverdatasets/. Accessed 04/09/09.

Foss, P. and Crushell, P. (2007). *Monaghan Fen Survey.* Report and accompanying GIS datasets prepared for Monaghan County Council and National Parks and Wildlife Service.

Foss, P. and Crushell, P. (2008). *National Fen Survey Manual.* Report prepared for National Parks and Wildlife Service.

Fossitt, J.A. (2000). *A Guide to Habitats in Ireland.* Heritage Council, Kilkenny.

Green, P.R. (2008). *Flora of County Waterford.* http://floraofcountywaterford.biodiversityireland.ie/. Accessed 04/09/09.

Hammond, R. (1978). *The Peatlands of Ireland.* 2nd edn. Soil Bulletin No. 35. An Foras Talúntais, Dublin.

Heywood, I., Cornelius, S. and Carver, S. (2006). *An Introduction to Geographical Information Systems.* Addison Wesley Longman, New York.

Hill, D.H., Fasham, M., Tucker, G., Shewry, M. and Shaw, P. (2005). *Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring.* Cambridge University Press, Cambridge.

Hill, M.O., Preston, C.D. and Roy, D.B. (2004). *PLANTATT. Attributes of British and Irish Plants: Status, Size, Life History, Geography and Habitats.* Natural Environment Research Council, Monks Wood.

Institute of Ecology and Environmental Management (2004). *Guidance for Access to Land.* Professional Issues Series 7. IEEM, Winchester.

Institute of Ecology and Environmental Management (2006a). *Guidelines for Ecological Impact Assessment in the United Kingdom.* IEEM, Winchester.

Institute of Ecology and Environmental Management (2006b). *Risk Assessment for Lone Workers.* Professional Issues Series 12. IEEM, Winchester. http://www.ieem.net/docs/12-Risk_Assessment_for_Lone_Workers.pdf. Accessed 04/09/09.

JNCC (2004). *Common Standards Monitoring Guidance for Lowland Wetland Habitats.* Joint Nature Conservation Committee, Peterborough.

JNCC (2007). *Handbook for Phase 1 Habitat Survey.* Joint Nature Conservation Committee, Peterborourgh [Revised Reprint published in 2003; 2007 Reprint]

Kaplan, E.D. (2005). *Understanding GPS: Principles and Applications.* 2nd edn. Artech House, Boston.

Kent, M. and Coker, P. (1992). *Vegetation Description and Analysis.* John Wiley & Sons, Chichester.

Legendre, P. & Legendre, L. (1998). *Numerical Ecology*, 2nd English edn. Elsevier, Amsterdam.

Lockhart, N., Madden, B., Wolfe-Murphy, S., Wymer, E. and Wyse Jackson, M. (1993). *National ASI Survey Guidelines for Ecologists.* National Parks and Wildlife Service, unpublished report.

Longley, P., Goodchild, M., Maguire, D. M. and Rhind, D. (2005). *Geographic Information Systems and Science.* Wiley, Chichester.

Magurran, A.E. (2004). *Measuring Biological Diversity.* Blackwell Publishing, Oxford.

Marine Institute (2010). Irish Spatial Data Exchange. http://www.marine.ie/isde/. Accessed 20/01/10.

Mark, D.M. (2003). Geographic Information Science: defining the field. In *Foundations in Geographic Information Science* (eds. Duckham, M., Goodchild. M.F. and Worboys M.F). Taylor and Francis, New York.

Marshall, T.F. (2009). Rural gardens, allotments and biodiversity. *British Wildlife.* Vol. 21 (2): 85-95.

Martin D. (1996). *Geographical Information Systems and their Socio-economic Applications.* 2nd edn. Routledge, London.

Martin J.R, Gabbett M. Perrin P.M, and Delaney A. (2007). *Semi-natural grassland survey of Counties Roscommon and Offaly*. National Parks and Wildlife Service, unpublished report.

McCune, B. and Grace, J.B. (2002). *Analysis of Ecological Communities.* MjM Software Design, Oregon.

Mitchell, A. (2005). *The ESRI Guide to GIS Analysis, Volume 2: Spatial Measurements and Statistics.* ESRI Press, 380 New York Street, Redlands, California.

Monmonier, M. (1996). *How to lie with maps.* The University of Chicago Press, Chicago.

Murray, A. and Foulkes, N. (2006). A methodology for the recording of hedgerow extent, species composition, structure and condition in Ireland. *Tearmann* 5: 79-94.

National Botanic Gardens (2009). *Resources for Studying the Irish Flora.* http://www.botanicgardens.ie/herb/census/resource.htm. Accessed 15/01/10.

National Parks and Wildlife Service (2008). *The Status of EU Protected Habitats and Species in Ireland.* Department of the Environment, Heritage and Local Government, Dublin.

National Roads Authority (NRA) (2006). *A Guide to Landscape Treatments for National Road Schemes.* National Roads Authority, Dublin.

National Roads Authority (NRA) (2009). *Guidelines for Assessment of Ecological Impacts of National Road Schemes.* National Roads Authority, Dublin.

Natura Environmental Consultants (2002, 2005). *Habitat Survey Guidelines: A Standard Methodology for Habitat Survey in Ireland.* Draft reports prepared for the Heritage Council.

O'Donoghue, P. O'Hora, K, Gittings, T. and Delaney, E. (2009). *Midleton Area Habitat Survey and Mapping Project 2009.* Final Report prepared for Cork County Council. Atkins, Cork.

Ordnance Survey Ireland (2008a). *Project planning for the transformation of geographic data from Irish Grid (IG) to Irish Transverse Mercator (ITM).* http://www.osi.ie/en/alist/migrating-to-itm.aspx. Accessed 04/09/09.

Ordnance Survey Ireland (2008b). *Ortho Photography.* Product Specification Sheet. http://www.osi.ie/en/alist/product-specification-sheets.aspx. Accessed 04/09/09.

Ordnance Survey Ireland (2008c). *High Resolution Ortho Photography.* Product Specification Sheet. http://www.osi.ie/en/alist/product-specification-sheets.aspx. Accessed 04/09/09.

Ordnance Survey Ireland (2009). *Irish Grid Reference System.* http://www.osi.ie/en/alist/reference-information.aspx?article=42177d93-831a-4c6c-8ebf-cef57b55cd93. Accessed 04/09/09.

Parr, S., O'Donovan, G. and Finn, J. (2005) *Mapping the Broad Habitats of the Burren Using Satellite Imagery.* End of Project Report. Teagasc, Wexford.

Paton, J.A. (1999). *The Liverwort Flora of the British Isles.* Harley Books, Colchester.

Perrin, P., Martin, J., Barron, S., O'Neill, F., McNutt, K. and Delaney, A. (2008a). *National Survey of Native Woodlands 2003-2008. Vol. I: Main Report.* Report prepared for NPWS.

Perrin, P., Martin, J., Barron, S., O'Neill, F., McNutt, K. and Delaney, A. (2008b). *National Survey of Native Woodlands 2003-2008. Vol. II: Woodland Classification.* Report prepared for NPWS.

LITERATURE CITED

Pethybridge, G.H. and Praeger, R.L. (1905). The vegetation of the district lying south of Dublin. *Proceedings of the Royal Irish Academy* 25B: 124-180.

Praeger, R.L. (1911). Clare Island Survey. Part 10. Phanerogamia and Pteridophyta. *Proceedings of the Royal Irish Academy* 31: 1-112.

Preston, C.D., Pearman, D.A. and Dines T.D. (2002). *New Atlas of British and Irish Flora.* Oxford University Press.

Ratcliffe, D.A. (ed.) (1977). *A Nature Conservation Review.* Cambridge University Press, Cambridge.

Rodwell, J.S. (ed.) (1991a). *Woodlands and Scrub.* British Plant Communities, Vol. 1. Cambridge University Press, Cambridge.

Rodwell, J.S. (ed.) (1991b). *Mires and Heaths.* British Plant Communities, Vol. 2. Cambridge University Press, Cambridge.

Rodwell, J.S. (ed.) (1992). *Grasslands and Montane Communities.* British Plant Communities, Vol. 3. Cambridge University Press, Cambridge.

Rodwell, J.S. (ed.) (1995). *Aquatic Communities, Swamps and Tall-Herb Fens.* British Plant Communities, Vol. 4. Cambridge University Press, Cambridge.

Rodwell, J.S. (ed.) (2000a). *Maritime Communities and Vegetation of Open Habitats.* British Plant Communities, Vol. 5. Cambridge University Press, Cambridge.

Rodwell, J.S. (2000b). *A Phytosociological Conspectus of British Plant Communities.* Report prepared for JNCC.

Rodwell, J.S. (2006) *National Vegetation Classification: Users' Handbook.* Joint Nature Conservation Committee, Peterborough.

Royal Institute of Chartered Surveyors (2003). *Guidelines for the Use of GPS in Surveying and Mapping.* RICS Books, Coventry.

RPS Consultants (2001). *N25 Waterford Bypass Environmental Impact Statement.* RPS Consultants, Cork.

Schouten, M.G.C. (1984). Some aspects of the ecogeographical gradient in the Irish ombrotrophic bogs. *Proceedings of the 7th International Peat Congress* 1: 414-432.

Skelton, R.A. (1972). *Maps: A Historical Survey of Their Study and Collecting.* University of Chicago Press, Chicago.

Smith, A.J.E. (2004). *The Moss Flora of Britain and Ireland.* 2nd edition. Cambridge University Press, Cambridge.

Speight, M.C.D, (2008). *Database of Irish Syrphidae.* Irish Wildlife Manual 36. National Parks and Wildlife Service, Dublin.

Stace, C.A. (2010). New Flora of the British Isles. 3rd edition. Cambridge University Press, Cambridge.

Stevens, J.P., Blackstock, T.H., Howe, E.A. and Stevens, D.P. (2004). Repeatability of Phase 1 habitat survey. *Journal of Environmental Management* 73: 53-59.

Tansley, A.G. (1949). *The British Islands and Their Vegetation.* Vols. 1 and 2. Cambridge University Press, Cambridge.

Thompson, K. (2007). *No Nettles Required. The Reassuring Truth about Wildlife Gardens.* Eden Project Books.

Webb, D.A. (1980). The Biological Vice-Counties Of Ireland. *Proceedings of the Royal Irish Academy* 80B: 179-196.

White, J. (2006). Visual representations of Irish vegetation. *Biology and Environment* 106B: 189-198.

White, J. and Doyle, G.J. (1982). The vegetation of Ireland: a catalogue raisonné. *Journal of Life Sciences, Royal Dublin Society* 3: 289-368.

Worboys, M. and Duckham M. (2004). *GIS: A Computing Perspective*, 2nd ed. CRC Press LLC, Florida.

APPENDIX A *GUIDE TO HABITATS* (FOSSITT, 2000) CLASSIFICATION: NON-MARINE

F FRESHWATER	
FL Lakes and Ponds	FL1 Dystrophic lakes
	FL2 Acid oligotrophic lakes
	FL3 Limestone/marl lakes
	FL4 Mesotrophic lakes
	FL5 Eutrophic lakes
	FL6 Turloughs
	FL7 Reservoirs
	FL8 Other artificial lakes and ponds
FW Watercourses	FW1 Eroding/upland rivers
	FW2 Depositing/lowland rivers
	FW3 Canals
	FW4 Drainage ditches
FP Springs	FP1 Calcareous springs
	FP2 Non-calcareous springs
FS Swamps	FS1 Reed and large sedge swamps
	FS2 Tall-herb swamps
G GRASSLAND AND MARSH	
GA Improved grassland	GA1 Improved agricultural grassland
	GA2 Amenity grassland (improved)
GS Semi-natural grassland	GS1 Dry calcareous and neutral grassland
	GS2 Dry meadows and grassy verges
	GS3 Dry-humid acid grassland
	GS4 Wet grassland
GM Freshwater marsh	GM1 Marsh
H HEATH AND DENSE BRACKEN	
HH Heath	HH1 Dry siliceous heath
	HH2 Dry calcareous heath
	HH3 Wet heath
	HH4 Montane heath
HD Dense bracken	HD1 Dense bracken
P PEATLANDS	
PB Bogs	PB1 Raised bogs
	PB2 Upland blanket bog

	PB3 Lowland blanket bog
	PB4 Cutover bog
	PB5 Eroding blanket bog
PF Fens and Flushes	PF1 Rich fen and flush
	PF2 Poor fen and flush
	PF3 Transition mire and quaking bog
W WOODLAND AND SCRUB	
WN Semi-natural woodland	WN1 Oak-birch-holly woodland
	WN2 Oak-ash-hazel woodland
	WN3 Yew woodland
	WN4 Wet pedunculate oak-ash woodland
	WN5 Riparian woodland
	WN6 Wet willow-alder-ash woodland
	WN7 Bog woodland
WD Highly modified/non-native woodland	WD1 (Mixed) broadleaved woodland
	WD2 Mixed broadleaved/conifer woodland
	WD3 (Mixed) conifer woodland
	WD4 Conifer plantation
	WD5 Scattered trees and parkland
WS Scrub/transitional woodland	WS1 Scrub
	WS2 Immature woodland
	WS3 Ornamental/non-native shrub
	WS4 Short rotation coppice
	WS5 Recently-felled woodland
WL Linear woodland/scrub	WL1 Hedgerows
	WL2 Treelines
E EXPOSED ROCK AND DISTURBED GROUND	
ER Exposed rock	ER1 Exposed siliceous rock
	ER2 Exposed calcareous rock
	ER3 Siliceous scree and loose rock
	ER4 Calcareous scree and loose rock
EU Underground rock and caves	EU1 Non-marine caves
	EU2 Artificial underground habitats

APPENDIX A *GUIDE TO HABITATS* (FOSSITT, 2000) CLASSIFICATION: NON-MARINE

ED Disturbed ground	ED1 Exposed sand, gravel or till
	ED2 Spoil and bare ground
	ED3 Recolonising bare ground
	ED4 Active quarries and mines
	ED5 Refuse and other waste
B CULTIVATED AND BUILT LAND	
BC Cultivated land	BC1 Arable crops
	BC2 Horticultural land
	BC3 Tilled land
	BC4 Flower beds and borders
BL Built land	BL1 Stone walls and other stonework
	BL2 Earth banks
	BL3 Buildings and artificial surfaces
C COASTLAND	
CS Sea cliffs and islets	CS1 Rocky sea cliffs
	CS2 Sea stacks and islets
	CS3 Sedimentary sea cliffs
CW Brackish waters	CW1 Lagoons and saline lakes
	CW2 Tidal rivers
CM Salt marshes	CM1 Lower salt marsh
	CM2 Upper salt marsh
CB Shingle and gravel banks	CB1 Shingle and gravel banks
CD Sand dune systems	CD1 Embryonic dunes
	CD2 Marram dunes
	CD3 Fixed dunes
	CD4 Dune scrub and woodland
	CD5 Dune slacks
	CD6 Machair
CC Coastal constructions	CC1 Sea walls, piers and jetties
	CC2 Fish cages and rafts

APPENDIX B CORRESPONDENCE BETWEEN EU HABITATS DIRECTIVE AND A *GUIDE TO HABITATS* CLASSIFICATIONS

The following table shows the correspondences between non-marine habitats as classified in the *Guide to Habitats* and Habitats Directive habitats. These correspondences have been produced by NPWS (pers. comm.) and differ slightly from those in the *Guide to Habitats*. In some cases, such as turloughs and yew woodlands, the correspondences are exact. However, in most cases, only certain examples of *Guide to Habitats* habitats can also be considered an example of the corresponding Habitats Directive habitat. In addition, some examples of different *Guide to Habitats* habitats can be considered as examples of the same Habitats Directive habitat.

Non-Marine Habitat Categories in the *Guide to Habitats*	EU Habitats Directive Annex I habitat types (* = priority type)
FRESHWATER	
FL1 Dystrophic lakes	Natural dystrophic lakes and ponds (3160)
FL2 Acid oligotrophic lakes	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) (3110)
	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea (3130)
FL3 Limestone/marl lakes	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp. (3140)
FL4 Mesotrophic lakes	
FL5 Eutrophic lakes	Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation (3150)
FL6 Turloughs	*Turloughs (3180)
FL7 Reservoirs	
FL8 Other artificial lakes and ponds	
FW1 Eroding/upland rivers	Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)
FW2 Depositing/lowland rivers	Watercourses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)
	Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270)
FW3 Canals	
FW4 Drainage ditches	
FP1 Calcareous springs	*Petrifying springs with tufa formation (Cratoneurion) (7220)
FP2 Non-calcareous springs	
FS1 Reed and large sedge swamps	

APPENDIX B CORRESPONDENCE BETWEEN EU HABITATS DIRECTIVE AND *GUIDE TO HABITATS* CLASSIFICATIONS

Non-Marine Habitat Categories in the *Guide to Habitats*		EU Habitats Directive Annex I habitat types (* = priority type)
FS2	Tall-herb swamps	Hydrophilous tall-herb fringe communities of plains and of the montane to alpine levels (6430)
GRASSLAND AND MARSH		
GA1	Improved agricultural grassland	
GA2	Amenity grassland (improved)	
GS1	Dry calcareous and neutral grassland	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometea) (*important orchid sites) (6210)
		Juniperus communis formations on heaths or calcareous grasslands (5130)
		Calaminarian grasslands of the Violetalia calaminariae (6130)
GS2	Dry meadows and grassy verges	Lowland hay meadows *(Alopecurus pratensis, Sanguisorba officinalis)* (6510)
GS3	Dry-humid acid grassland	*Species-rich *Nardus* grasslands on siliceous substrates in mountain areas (and submountain areas in continental Europe) (6230)
		Calaminarian grasslands of the Violetalia calaminariae (6130)
GS4	Wet grassland	*Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) (6410)
GM1	Marsh	Hydrophilous tall-herb fringe communities of plains and of the montane to alpine levels (6430)
HEATH AND DENSE BRACKEN		
HH1	Dry siliceous heath	European dry heaths (4030)
		Juniperus communis formations on heaths or calcareous grasslands (5130)
HH2	Dry calcareous heath	European dry heaths (4030)
		Juniperus communis formations on heaths or calcareous grasslands (5130)
HH3	Wet heath	Northern Atlantic wet heaths with *Erica tetralix* (4010)
HH4	Montane heath	Alpine and Boreal heaths (4060)
HD1	Dense bracken	

Non-Marine Habitat Categories in the *Guide to Habitats*		EU Habitats Directive Annex I habitat types (* = priority type)
PEATLANDS		
PB1	Raised bog	*Active raised bogs (7110)
		Degraded raised bogs still capable of natural regeneration (7120)
		Depressions on peat substrates of the Rhynchosporion (7150)
PB2	Upland blanket bog	Blanket bog (*if active bog) (7130)
		Depressions on peat substrates of the Rhynchosporion (7150)
PB3	Lowland blanket bog	Blanket bog (*if active bog) (7130)
		Depressions on peat substrates of the Rhynchosporion (7150)
PB4	Cutover bog	Depressions on peat substrates of the Rhynchosporion (7150)
PB5	Eroding blanket bog	
PF1	Rich fen and flush	*Calcareous fens with *Cladium mariscus* and species of the Caricion davallianae (7210)
		Alkaline fens (7230)
PF2	Poor fen and flush	
PF3	Transition mire and quaking bog	Transition mires and quaking bogs (7140)
WOODLAND AND SCRUB		
WN1	Oak-birch-holly woodland	Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles (91A0)
WN2	Oak-ash-hazel woodland	
WN3	Yew woodland	**Taxus baccata* woods of the British Isles (91J0)
WN4	Wet pedunculate oak-ash woodland	*Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-padion, Alnion incanae, Salicion albae) (91E0)
WN5	Riparian woodland	*Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-padion, Alnion incanae, Salicion albae) (91E0)
WN6	Wet willow-alder-ash woodland	
WN7	Bog woodland	*Bog woodland (91D0)
WD1	(Mixed) broadleaved woodland	
WD2	Mixed broadleaved/conifer woodland	

APPENDIX B CORRESPONDENCE BETWEEN EU HABITATS DIRECTIVE AND *GUIDE TO HABITATS* CLASSIFICATIONS

Non-Marine Habitat Categories in the *Guide to Habitats*	EU Habitats Directive Annex I habitat types (* = priority type)
WD3 (Mixed) conifer woodland	
WD4 Conifer plantation	
WD5 Scattered trees and parkland	
WS1 Scrub	*Juniperus communis* formations on heaths or calcareous grasslands (5130)
WS2 Immature woodland	
WS3 Ornamental/non-native shrub	
WS4 Short rotation coppice	
WS5 Recently-felled woodland	
WL1 Hedgerows	
WL2 Treelines	
EXPOSED ROCK AND DISTURBED GROUND	
ER1 Exposed siliceous rock	Siliceous rocky slopes with chasmophytic vegetation (8220)
ER2 Exposed calcareous rock	Calcareous rocky slopes with chasmophytic vegetation (8210) *Limestone pavements (8240)
ER3 Siliceous scree and loose rock	Siliceous scree of the montane to snow levels (Androsacetalia alpinae and Galeopsietalia ladani) (8110)
ER4 Calcareous scree and loose rock	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii) (8120)
EU1 Non-marine caves	Caves not open to the public (8310)
EU2 Artificial underground habitats	
ED1 Exposed sand, gravel or till	
ED2 Spoil and bare ground	
ED3 Recolonising bare ground	
ED4 Active quarries and mines	
ED5 Refuse and other waste	
CULTIVATED AND BUILT LAND	
BC1 Arable crops	
BC2 Horticultural land	

Non-Marine Habitat Categories in the *Guide to Habitats*	EU Habitats Directive Annex I habitat types (* = priority type)
BC3 Tilled land	
BC4 Flower beds and borders	
BL1 Stone walls and other stonework	
BL2 Earth banks	
BL3 Buildings and artificial surfaces	
COASTLAND	
CS1 Rocky sea cliffs	Vegetated sea cliffs of the Atlantic and Baltic coasts (1230)
CS2 Sea stacks and islets	Vegetated sea cliffs of the Atlantic and Baltic coasts (1230)
CS3 Sedimentary sea cliffs	Vegetated sea cliffs of the Atlantic and Baltic coasts (1230)
CW1 Lagoons and saline lakes	*Coastal lagoons (1150)
CW2 Tidal rivers	Estuaries (1130)
CM1 Lower salt marsh	*Salicornia* and other annuals colonising mud and sand (1310)
	Spartina swards (Spartinion maritimae) (1320)
	Atlantic salt meadows (Glauco-Puccinellietalia maritimae) (1330)
	Mediterranean and thermo-Atlantic halophilous scrubs (Sarcocornetea fruticosi) (1420)
CM2 Upper salt marsh	Atlantic salt meadows (Glauco-Puccinellietalia maritimae) (1330)
	Mediterranean salt meadows (Juncetalia maritimi) (1410)
CB1 Shingle and gravel banks	Perennial vegetation of stony banks (1220)
CD1 Embryonic dunes	Embryonic shifting dunes (2110)
CD2 Marram dunes	Shifting dunes along the shoreline with Ammophila arenaria (‘white dunes’) (2120)
CD3 Fixed dunes	*Fixed coastal dunes with herbaceous vegetation (‘grey dunes’) (2130)
	*Decalcified fixed dunes with *Empetrum nigrum* (2140)
	*Atlantic decalcified fixed dunes (Calluno-Ulicetea) (2150)
	Dunes with *Salix repens* ssp. *argentea* (Salicion arenariae) (2170)

APPENDIX B CORRESPONDENCE BETWEEN EU HABITATS DIRECTIVE AND *GUIDE TO HABITATS* CLASSIFICATIONS

Non-Marine Habitat Categories in the *Guide to Habitats*		EU Habitats Directive Annex I habitat types (* = priority type)
CD4	Dune scrub and woodland	Dunes with *Hippophae rhamnoides* (2160)
CD5	Dune slacks	Dunes with *Salix repens* ssp. *argentea* (Salicion arenariae) (2170)
		Humid dune slacks (2190)
CD6	Machair	Machairs (*in Ireland) (21A0)
CC1	Sea walls, piers and jetties	
CC2	Fish cages and rafts	

APPENDIX C GEOGRAPHICAL HABITAT DATASETS

CORINE

CORINE Land Cover (CLC) is a map of the European environmental landscape based on interpretation of satellite images gathered through a European Commission programme. CORINE stands for *Coordination of Information on the Environment*. A complete CORINE Land Cover dataset is available for the whole of Europe at a scale of 1:100,000.

The CORINE datasets follow a standardised, hierarchical nomenclature of land cover types. It operates on three levels, with five broad categories in the first level – artificial surfaces, agricultural areas, forest and semi-natural areas, wetlands and water bodies – and 44 categories in the third level. Land cover is classified by interpretation of Landsat TM satellite image maps, together with topographic maps and ground truthing.

This project was first undertaken in 1989-90 and later updated in 2000 and 2006. The CORINE datasets available for Ireland include:

- Revised National Corine 1990 (CLC1990)
- National Corine 2000 (CLC2000)
- Corine Land Cover change 1990-2000

The first CORINE project was undertaken in 1990. In Ireland, it was a joint venture between the OSi and OSNI. The main aim of this survey was to produce a cross-border land cover map for the entire island of Ireland. This dataset was later revised to correct geometric inaccuracies and classification issues in relation to certain land cover classes. This dataset became known as Revised National Corine 1990.

New satellite imagery was captured in 2000 and a new dataset was constructed that year, known as the National Corine 2000 dataset.

The Corine Land Cover change 1990-2000 dataset contains data on land cover changes larger than 5 ha between 1990 and 2000. Satellite imagery from 2000 was captured and compared to imagery captured as part of the 1990 survey.

At the time of writing, the EPA – in conjunction with the European Environment Agency, the European Space Agency and the European Commission – is working on a new dataset of changes in land cover between 2000 and 2006.

CORINE land use is of limited use to small-scale habitat mapping, as spatial resolution and the habitat classification are too coarse. However, it may be beneficial when undertaking large-scale habitat mapping. The mapping units in CORINE are large and the minimum identifiable area is 25 ha. Some land cover types can be broadly linked with some of the habitat categories of the *Guide to Habitats*, but correspondence is not exact.

The competent authority for managing and distributing CORINE data for Ireland is the EPA. CORINE data are freely available (EPA, 2008), subject to completion of an end-user agreement.

NPWS DATA

The National Parks and Wildlife Service (NPWS) is responsible for a number of datasets, including designated area boundaries, records of notable species, and data from ecological surveys commissioned by NPWS.

Designated sites are sites which have been legally designated to protect a range of habitats and species in Ireland. These include cSACs, SPAs and NHAs. Site boundaries have been digitised in GIS from hard copy field survey mapping at 1:15,000 (on reduced 1:10,560 mapping). Designated site datasets are available to download or view on a county-by-county basis from the NPWS (http://www.npws.ie/en/MapsData/). These also include proposed NHAs. Data formats available to download are Autodesk AutoCAD DWG/ DXF, Microstation Design Files (DGN), ESRI Shapefile, MapInfo TAB and ESRI ArcInfo Export (E00).

APPENDIX C GEOGRAPHICAL HABITAT DATASETS

Other habitat data from a variety of sources is held by the NPWS in GIS and other digital formats. This includes data extracted from published research and postgraduate theses. Many of these datasets are site-specific but may prove beneficial when undertaking habitat mapping in these areas. Habitat maps following the *Guide to Habitats* and Habitats Directive classifications are available for some designated areas. A summary of datasets available from NPWS is provided in the table below.

Dataset	Dates	Scope/Purpose of Dataset
Coastal Monitoring Project	2004-2006	Comprehensive baseline monitoring survey of Irish sand dune and machair sites
Lagoon Database	1996-2006	Comprehensive national survey of Irish lagoon sites
Salt marsh Monitoring Project	2006-2009	Baseline monitoring survey of a representative sample of Irish salt marshes
National Sea cliff survey	2009-ongoing	Baseline monitoring survey of Irish sea cliffs
National Shingle Beach Survey	1999	Inventory survey of shingle beach sites and their conservation value
Survey of intertidal mudflats & sandflats	2006-2007	Detailed survey of sedimentary and biological facies in representative sites
National Survey of Native Woodlands	2003-2007	Extensive inventory of native woodland sites in Ireland
National Fen Database	up to 2006	To consolidate information on the extent and Conservation Status of Irish Springs, Fens and Flushes based on existing information held by the National Parks & Wildlife Service and by other interested parties
Grassland Monitoring Project	2006	Grassland monitoring of a representative sample of the Habitats Directive Annex I habitats 6230 (Species-rich Nardus grasslands) and 6210 (Semi-natural dry grasslands) in Natura 2000 sites
Irish Semi-natural Grassland survey	2007-ongoing	Survey of semi-natural grasslands and marsh communities in Roscommon & Offaly (2007); Cork & Waterford (2008); Cavan, Monaghan, Leitrim, Longford (2009)
Metalliferous mine waste survey	2008	Survey of metalliferous mine waste sites in Ireland, which hold areas of the Habitats Directive Annex I habitat 6130 (Calaminarian grassland)
National Limestone Pavement Survey	2008-ongoing	Map of the range, extent and condition of limestone pavement in Ireland
Consolidated Turlough dataset	up to 2008	Documenting the distribution of the national turlough resource
Turf cutting assessment projects	1994-2006	Raised Bog Restoration/Assessment of Impacts of Turf Cutting on Designated Raised Bogs
Raised Bog Monitoring Project	2004-2005	Monitoring survey of 48 Irish raised bog sites
National Survey of Upland Habitats	2008-ongoing	Baseline monitoring survey of Irish upland habitats (over 150 metre altitude)

Dataset	Dates	Scope/Purpose of Dataset
Commonage Datasets	ongoing	Data on the condition of lands held in commonage. Habitat mosaics are identified within condition assessment units
Conservation Planning Habitat Maps	1995-ongoing	Habitat data for conservation planning of SACs / SPAs
Conservation Assessments data	2007	Datasets used for the 2007 Conservation Assessment under Article 17 of the Habitats Directive, with habitats mapped at a 10 km square level. These are derived from sources varying in quality and currency, and include best expert judgment where necessary. Full details are available in the backing documents which accompany the datasets.

Data is provided from the NPWS to users under the following understanding:
- Users of the data respect the policy of NPWS on restrictions of access to sensitive data
- Users acknowledge NPWS as the originators of the records in all uses of these data
- Users provide NPWS, upon request, with copies of any reports or publications resulting from the use of these data

Geology
The Geological Survey of Ireland (GSI) is the National Earth Science Agency. It produces a number of GIS-based geological datasets in IG that are of interest to habitat mapping. In particular:
- Bedrock geology: a seamless bedrock geological dataset with full Ireland coverage, available at 1:100,000 and 1:500,000 scales
- Karst features: a dataset of karst geology point features in the Republic of Ireland showing locations and other data for caves, depressions, springs, swallow holes, turloughs and other features
- Active quarries: a dataset of active quarries in the Republic of Ireland provided as point features
- Turloughs: a dataset of 235 turloughs and 244 potential turloughs from GSI, NPWS and other data sources

GSI datasets are available to view or download from the GSI website (http://www.gsi.ie) and their use is subject to a data user agreement. Comprehensive metadata are available from the webviewer.

National Soils, Subsoils and Indicative Habitat Mapping Data
The EPA Soil and Subsoil Mapping Project produced three GIS datasets mapping soils, subsoils and parent materials and indicative habitats. The project was completed in 2006. It was an extension of the earlier Teagasc Irish Forest Soils project (FIPS-IFS). This project compiled earlier detailed field-base soil mapping data and developed a methodology based on remote sensing and GIS for producing a first-approximation soil classification for unsurveyed areas. GSI also contributed to the EPA Soil and Subsoil Mapping Project. Good metadata and a project methodology report (Fealy *et al.*, 2006) exist for these datasets. These datasets are freely available from the EPA, subject to a user agreement.

National Subsoils Data
This dataset provides subsoil mapping and classification for the Republic of Ireland. It was derived from interpretation of aerial photography (from 1995) and compilation of published soil parent material, subsoil and geological data. Desktop data were supplemented with field data collected in 1998-2005. Mapping is in IG at a scale of approximately 1:50,000, with some features captured at a 900 m^2 resolution.

National Soils Data
This dataset provides indicative soil mapping and classification for the Republic of Ireland. It was derived from a model combining National Subsoils Data and a land cover map. The land cover map was derived from interpretation of Landsat TM imagery using training data derived from

APPENDIX C GEOGRAPHICAL HABITAT DATASETS

interpretation of aerial photography (from 1995) and ground truthing using the *Guide to Habitats*. Land cover classes produced were: Dry Grassland, Wet Grassland, Bog and Heath, Cut Bog, Cut & Eroding Bog, Rocky Complex, Bare Rock, Mature Forest, Forest (unclosed) & Scrub, Built Land, Coastal Complex, and Water. Mapping is in IG at a scale of approximately 1:40,000. Correspondence between soil mapping units and Great Soil Groups used for soil classification in Ireland is provided in the project methodology report (Fealy *et al.*, 2006).

Indicative Habitat Mapping Data

This dataset provides a map and classification of predicted habitat types for 20 counties in Ireland: Cork, Cavan, Carlow, Donegal, Dublin, Galway, Kilkenny, Kerry, Longford, Louth, Laois, Monaghan, Mayo, Roscommon, Sligo, Tipperary, Waterford, Westmeath, Wicklow and Wexford. It is an enhancement of the land cover map outlined above at greater classification and spatial resolution. The indicative habitat map was derived from the land cover data above in conjunction with subsoil data, DTMs and the Ireland Peatland Map (Hammond, 1978) using an expert rule base. Indicative habitat types and their correspondence with the *Guide to Habitats* classification are presented below (from Fealy *et al.*, 2006). Mapping is in IG.

CODE	HABITAT INDICATOR CLASS	CODE (Fossitt, 2000)
GSW	*Wet Grassland*	GA1, GA2, GS4
GAGS	*Dry Grassland*	GA1, GA2, GS1, GS2, GS3, BC1, BC2, BC3, BC4
FM	*Water*	FL1, FL2, FL3, FL4, FL5, FL6, FL7, FL8, CW1, CW2
ER	*Bare Rock*	ER1, ER2, ER3, ER4, CS1, CS2, CS3
CR	*Rocky Complex*	ER1, ER2, ER3, ER4, HH1, HH2, HH3, HH4, HD1
WNWD	*Mature Forest*	WN1, WN2, WN3 WN4, WN5, WN6, WN7, WD1, WD2, WD3, WD4
WSWL	*Forest (unclosed canopy) & Scrub*	WS1, WS2, WS3, WS4, WS5
BL	*Built Land*	BL3, GA2
CD	*Sand*	CD1, CD2, CD3
C	*Coastal Complex*	CD1, CD2, CD3, LR1, LR2, LR3, LR4, LR5, LS1, LS2, LS3, LS4, LS5
F	*Fen*	PF1, PF2, PF3
FC	*Cutover Fen*	PB4
FR	*Reclaimed Fen*	PB4
RBF	*Raised Bog/Fen*	PB1, PF1, PF2, PF3
RBFC	*Cutover Raised Bog/Fen*	PB4
RBFR	*Reclaimed Raised Bog/Fen*	PB4
UBB	*Upland Blanket Bog*	PB2
UBBC	*Cutover Upland Blanket Bog*	PB4

CODE	HABITAT INDICATOR CLASS	CODE (Fossitt, 2000)
UBBCE	*Cutover/Eroding Upland Blanket Bog*	PB4, PB5
UBBR	*Reclaimed Upland Blanket Bog*	PB4
LBB	*Lowland Blanket Bog*	PB3
LBBC	*Cutover Lowland Blanket Bog*	PB4
LBBCE	*Cutover/Eroding Lowland Blanket Bog*	PB4, PB5
LBBR	*Reclaimed Lowland Blanket Bog*	PB4
H	*Heath*	HH1, HH2, HH3, HH4, HD1
W	*Wetland*	GS4, GM1, PF1, PF2, PF3, FS1, FS2
CM	*Salt Marsh*	CM1, CM2

EPA SECURE ARCHIVE FOR ENVIRONMENTAL RESEARCH DATA

The Environmental Research Centre (ERC) of the EPA supports an internet-based research archive known as the Secure Archive for Environmental Research Data (SAFER-Data). Information available includes GIS and other data and research reports from EPA-sponsored research. Archive data are categorised in eight main themes, the most relevant of which for habitat mapping are: biodiversity; water quality; land use, soils and transport; and climate change. Some data are available for immediate download, but contacting the ERC or data owners is necessary for other data sources.

The most immediately relevant dataset in SAFER-Data for habitat mapping is the Turlough Database. This contains geographical and topographical data for 285 turloughs in counties Mayo, Roscommon, Galway and Clare. The information comprising this database has been drawn from NPWS data, the GSI karst database, Trinity College Dublin research archives on turloughs, and Ordnance Survey 1:50,000 topographic data. This database provides information on each turlough habitat including site name, location and environmental impacts on each turlough habitat. It should be noted that a more comprehensive turlough database is held by the NPWS and is available on the GSI online map viewer.

FOREST SERVICE SPATIAL DATABASE

In 1995, the Forest Service produced a digitally mapped inventory of forests and woodlands in the Republic of Ireland called FIPS95. Forests were classified from data gathered from satellite imagery, orthophotography and OSi 25-inch maps into 20 broad species and development classes.

The original database was updated with current forest inventory data in 1998 and 2006, and the latest revised dataset is known as Forest07. This dataset also includes information on planting year and species for post-1995 data. According to the Forest Service, the Forest07 dataset provides details on over 700,000 ha of Ireland's forest estate.

Forest classes from the Forest07 database are not directly equivalent to the *Guide to Habitats* classifications, but still provide useful information on whether a forest is broadleaf, conifer or mixed, whether a stand is young or mature, and sometimes an indication of the main tree species.

Further information on the dataset, future revisions and access should be sought from the Forest Service (2009).

APPENDIX D SOURCES OF HABITAT INFORMATION AND OTHER REFERENCES[15]

General Habitat Information Sources

County, Regional and Local Floras

County, Regional and Local Bird Faunas

National Parks and Wildlife Service Conservation Management Plans for Natura 2000 Sites

Areas of Scientific Interest – County Reports: http://www.npws.ie/en/PublicationsLiterature/ASICountyReports/

European Habitats and Species – Conservation Status Reports: http://www.npws.ie/en/PublicationsLiterature/ConservationStatusReport/Habitats/

County surveys of particular habitat types, *e.g.* hedgerows, wetlands etc.

Publications, reports and theses on habitats and ecology of particular sites

Mapviewers

National Biodiversity Data Centre mapviewer: http://maps.biodiversityireland.ie/

EPA mapviewer: http://maps.epa.ie/

National Parks and Wildlife Service mapviewer: http://www.npws.ie/en/MapsData/

Department of Communications, Marine and Natural Resources (including GSI) mapviewers and spatial data: http://www.dcenr.gov.ie/Spatial+Data/

OSi mapviewer: http://ims0.osiemaps.ie/website/publicviewer/main.aspx

National Flood Hazard Mapping: http://www.floodmaps.ie/

Specific Habitat Information Sources (list not comprehensive)

Alexander, K.N.A., Hope, J.C.E., Lucas, A., Smith, J.P. and Wright, M.A. (2007). *Wood Pasture and Parkland Scoping Study 2006.* Research and Development Series No. 08/01. Environment & Heritage Service, Belfast.

Averis, A.B.G. and Stewart, N.F. (1995). *Important Areas for Bryophyte Diversity in Ireland.* European Committee for Conservation of Bryophytes, Trondheim.

Bellamy, D. and Bellamy, R. (1966). An ecological approach to the classification of the lowland mires of Ireland. *Proceedings of the Royal Irish Academy* 65B: 237-251.

Boatman, D. J. (1961). Vegetation and peat characteristics of blanket bogs in County Kerry. *Journal of Ecology* 49: 507-517.

Botanical Environmental and Conservation Consultants (2006). *County Monaghan wetland survey.* A report prepared for Monaghan County Council.

Byrne, C., Kelly, D. L. and Jeffrey, D. W. (1997). An experimental study of floristic composition in semi-natural grassland in eastern Ireland. In *Management for Grassland Biodiversity*, vol. 2, pp. 207-213. European Grassland Federation, Poland.

Conaghan, J. (2001). *A Review Study of Heathlands in Ireland*. Report prepared for the Heritage Council.

Conaghan, J. (2001). *The Distribution, Ecology and Conservation of Blanket Bog in the Republic of Ireland*. Report prepared for Dúchas.

[15] *URLs correct as of 4th September, 2009.*

Cooper, A., Murray, R. and McCann, T. (1995). The distribution and management of species rich grasslands in Northern Ireland. In *Irish Grasslands, Their Biology and Management* (ed. D. W. Jeffrey, M. Jones, B. & McAdam), pp. 219-227. Royal Irish Academy, Dublin.

Coxon C. E. (1987). The spatial distribution of turloughs. *Irish Geography* 20: 11-23.

Crawford I, Bleasdale A and Conaghan J. (1998). *BioMar Survey of Irish Machair Sites. Vol. 1. Site Information.* Irish Wildlife Manuals No. 3. Dúchas, the Heritage Service, Dublin.

Cross J.R. (1990). *The Raised Bogs of Ireland: their Ecology, Status and Conservation.* The Stationery Office, Dublin.

Cross, J.R. (1992). The distribution, character and conservation of woodlands on esker ridges in Ireland. *Proceedings of the Royal Irish Academy*, 92 B, 1-19.

Cross, J.R. (1998). An outline and map of the potential natural vegetation of Ireland. *Applied Vegetation Science*, 1: 241-252.

Cross, J.R. (2008). Irish native woodland classification. In *Native Woodland Scheme Manual*, pp. 71-91. Forest Service, Wexford.

Crowe, O. (2005). *Ireland's Wetlands and their Waterbirds: Status and Distribution*. BirdWatch Ireland, Rockingham, Co. Wicklow.

Crushell, P. (2000). *Irish Fen Inventory – a Review of the Status of Fens in Ireland*. Irish Peatland Conservation Council, Dublin.

Crushell, P. and Foss, P. (2008). *Clare Wetland Survey*. Report and accompanying GIS datasets prepared for Clare County Council and the Heritage Council.

Curtis, T.G.F (1991). A site inventory of the sandy coasts of Ireland. In *A Guide to the Sand Dunes of Ireland* (ed. M.B. Quigley), pp 6-17. European Union for Dune Conservation and Coastal Management.

Curtis, T.G.F and Sheehy Skeffington, M.J. (1998). The salt marshes of Ireland: an inventory and account of their geographical variation. *Biology and Environment: Proceedings of the Royal Irish Academy*, 98B, 87–104.

Doyle, G.J. (1982). The vegetation, ecology and productivity of Atlantic Blanket Bog in Mayo and Galway. *Journal of Life Sciences, Royal Dublin Society* 3: 147-164

Doyle, G.J. (1990). Phytosociology of Atlantic blanket bog complexes in north-west Mayo. In *Ecology & Conservation of Irish Peatlands* (ed. G. Doyle). Royal Irish Academy, Dublin.

Doyle, G.J. and Moore, J.J. (1980). Western blanket bog (Pleurozio purpureae – Ericetum tetralicis) in Ireland and Great Britain. *Coll. Phytosoc*. 7: 213-223.

Dwyer, R., Crowley, W. & Wilson, F. (2007) *Grassland Monitoring Project 2006*. Report prepared for National Parks and Wildlife Service.

Dwyer, R.B. (2000). *Protecting Nature in Ireland. The NGO Special Areas of Conservation Shadow List*. Report prepared by An Taisce, BirdWatch Ireland, Coastwatch Ireland, Irish Peatland Conservation Council and the Irish Wildlife Trust. IPCC, Dublin.

Eakin, AM. (1995). A botanical survey of conserved grassland in county Fermanagh. In *Irish Grasslands, Their Biology and Management* (ed. D. W. Jeffrey, M. B. Jones & McAdam), pp. 227-236. Royal Irish Academy, Dublin.

Eber, W. (1982). The ecology of bogs and bog plants. *Journal of Life Sciences, Royal Dublin Society* 3: 243-254.

Fernandez, F., Fanning, M., McCorry, M. and Crowley, W. (2005). *Raised Bog Monitoring Project 2004-05*. Report prepared for National Parks and Wildlife Service.

APPENDIX D SOURCES OF HABITAT INFORMATION AND OTHER REFERENCES

Foss, P. (2007). *Study of the Extent and Conservation Status of Springs Fens and Flushes in Ireland*. Report prepared for National Parks and Wildlife Service.

Foss, P. and Crushell, P. (2007). *Monaghan Fen Survey*. Report and accompanying GIS datasets prepared for Monaghan County Council and the National Parks and Wildlife Service.

Foss, P. and Crushell, P. (2008). *Monaghan Fen Survey II*. Report and accompanying GIS datasets prepared for Monaghan County Council and the National Parks and Wildlife Service.

Foss, P. and Crushell, P. (2008). *Guidelines for a National Fen Survey of Ireland*. Report prepared for the National Parks and Wildlife Service.

Foss, P. and Crushell, P. (2008). *National Fen Survey Manual*. Report prepared for National Parks and Wildlife Service.

Foss, P.J. (1998). National overview of the peatland resource in Ireland. In *Towards a Conservation Strategy for the Bogs of Ireland* (ed. G. O'Leary and F. Gormley), pp. 3-20. Irish Peatland Conservation Council, Dublin.

Foulkes, N. and Murray, A. (2005). *County Laois Hedgerow Survey Report*. A report prepared for Laois County Council.

Foulkes, N. and Murray, A. (2005). *County Roscommon Hedgerow Survey Report*. A report prepared for Roscommon County Council.

Fowles, A.P (2003). *Guidance notes for the definition and mapping of habitat quality of Marsh Fritillaries. Natural science report no. 03/05/01* – Countryside Council for Wales.

Fowles, A.P (2005). *Habitat mapping for Marsh Fritillary populations*. Staff Science Report 05/5/1 -Countryside Council for Wales.

Gaynor, K. (2006). The vegetation of Irish machair. *Biology and Environment* 106B: 311-321.

Goodwillie, R. (1992). *Turloughs Over 10ha: Vegetation Survey and Evaluation*. Report prepared for Office of Public Works.

Hammond, R.F. (1979). *The Peatlands of Ireland*. An Foras Talúntais, Dublin.

Heery, S. (1991). The plant communities of the grazed and mown grasslands of the River Shannon callows. *Proceeding of the Royal Irish Academy* 91: 1-19.

Hickey, B. and Tubridy, M. (2005). *Laois habitats survey 2005 – Volume I*. Report prepared for the Laois Heritage Forum: An action of the Laois Heritage Plan.

Hickey, B. and Tubridy, M. (2006). *Laois habitats survey 2005*. Report prepared for the Laois Heritage Forum: An action of the Laois Heritage Plan.

Holyoak, D.T. (2009). *Vegetation on Metalliferous Mine Waste in Ireland*. Report prepared for National Parks and Wildlife Service.

Ivimey-Cook, R.B. & Proctor, M.C.F. (1966). The plant communities of the Burren, Co. Clare. *Proceedings of the Royal Irish Academy* 64: 211-301.

Keane, S. and Sheehy-Skeffington, M. (1995). Vegetation in east Burren uplands in relation to landuse and conservation. *In Irish Grasslands, Their Biology and Management*. (eds. D.W. Jeffrey, M.B. Jones and J.H. McAdam), pp. 253-266. Royal Irish Academy, Dublin.

Kelly, D.L. and Iremonger, S.F. (1997). Irish wetland woods: the plant communities and their ecology. *Proceedings of the Royal Irish Academy* 97B: 1-32.

Kelly, L., Doak, M. and Dromey, M. (1995). *Raised Bog Restoration Project: an Investigation into the Conservation and Restoration of Selected Raised Bog Sites in Ireland*. Report prepared for National Parks and Wildlife Service.

Lyons, M. and Tubridy, M. (2006). *A survey of ancient and species rich hedgerows in Dublin City*. A report prepared for Dublin City Council.

Lyons, M. and Tubridy, M. (2007). *A survey of semi-natural grasslands in Dublin City*. A report prepared for Dublin City Council.

Martin, J.R. Gabbett, M. Perrin, P.M. and Delaney, A., (2007). *Semi-natural Grassland Survey of Counties Roscommon and Offaly*. Report prepared for National Parks and Wildlife Service (NPWS).

MERC Consultants Ltd. (2006). *Audit of biological datasets. County Westmeath*. Report prepared for Westmeath County Council.

Moore, J. J. (1968). A classification of the bogs and wet heaths of northern Europe (Oxycocco-Sphagnetea Br.-Bl. et Tx. 1943). In *Pflanzensoziologische Systematik* (ed. R. Tüxen), pp. 306-320. Junk, Den Haag.

Moore, J.J. (1962). The Braun-Blanquet system: a reassessment. *Journal of Ecology* 50, 761-769.

Murphy, S. and Fernandez, F. (2009). *The Development of Methodologies to Assess the Conservation Status of Limestone Pavement and Associated Habitats in Ireland*. Irish Wildlife Manuals No. 43. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin.

Muyllaert, M. and Tubridy, M. (2005). *Laois Esker Survey 2005*. Report prepared for Laois Heritage Forum. An action of the Laois Heritage Plan. Report prepared for Laois County Council.

National Biodiversity Data Centre (2010). *Taking a Grid Reference from an Ordnance Survey (OS) Map*. National Biodiversity Data Centre, Waterford. http://www.biodiversityireland.ie/wp-content/uploads/Taking-a-grid-reference.pdf. Accessed 12/02/10.

National Parks and Wildlife Service (2008). *The Status of EU Protected Habitats and Species in Ireland*. Department of the Environment, Heritage and Local Government, Dublin.

Natura Environmental Consultants (2003). *Dublin City: Natural Heritage Surveys*. A report prepared for Dublin City Council.

Natura Environmental Consultants (2005). *Galway City Habitat Inventory*. A report prepared for the Galway City Development Board and the Heritage Council.

Natura Environmental Consultants (2006). *County Waterford Wetlands Survey*. A report prepared for Waterford County Council.

Neff, J. A. (1998). *Irish Coastal Habitats: a study of impacts on designated conservation areas.* Heritage Council, Kilkenny.

O'Connell, M. (1990). Origins of Irish lowland blanket bog. In *Ecology and Conservation of Irish Peatlands* (ed. G.J. Doyle), pp. 49-71. Royal Irish Academy, Dublin.

Ó Críodáin, C., and Doyle, G.J., (1997). *Schoenetum nigricantis*, the *Schoenus* fen and flush vegetation of Ireland. *Biology and Environment* 97B: 203-218.

APPENDIX D SOURCES OF HABITAT INFORMATION AND OTHER REFERENCES

O'Donoghue, P., O'Hora, K. and Delaney, E. (December 2008) *Blarney Electoral District Habitat Mapping 2008*. Atkins (Ecology) Report prepared for Cork County Council. Atkins, Cork.

O'Donoghue, P., O'Hora, K, Gittings, T. and Delaney, E. (2009). *Midleton Area Habitat Survey and Mapping Project 2009*. Final Report prepared for Cork County Council. Atkins, Cork.

O'Donovan, G. (2007). *Lowland Grassland Survey of Sligo*. Report prepared for Sligo County Council.

O'Riain, G., Cullen, C. and Day, A. (2007). *Survey and mapping of habitats in the Carrigaline electoral area*. A report prepared for Cork County Council.

O'Sullivan, A.M. (1982). The lowland grasslands of Ireland. *Journal of Life Sciences, Royal Dublin Society* 3: 131-142.

O'Sullivan, A.M. (1968). Irish Molinietalia communities in relation to those of the Atlantic region of Europe. *Ber. Int. Symp.* 1964: 327-340.

O'Sullivan, A.M. (1968). *The Lowland Grasslands of Co. Limerick*. Irish Vegetation Studies. An Foras Talúntais, Dublin.

O'Sullivan, A.M. (1976). The phytosociology of the Irish wet grasslands belonging to the order Molinietalia. *Coll. Phytosoc*. 5: 259-267.

Otte, M.L. (2003). *Wetlands of Ireland: Distribution, Ecology, Uses and Economic Value*. University College Dublin Press, Dublin.

Perrin, P., Martin, J., Barron, S., O'Neill, F., McNutt, K. and Delaney, A. (2008a). *National Survey of Native Woodlands 2003-2008. Vol. I: Main Report*. Report prepared for NPWS.

Perrin, P., Martin, J., Barron, S., O'Neill, F., McNutt, K. and Delaney, A. (2008b). National Survey of Native Woodlands 2003-2008. Vol. II: Woodland Classification. Report prepared for NPWS.

Reynolds, S. (2002). *A Catalogue of Alien Plants in Ireland*. National Botanic Gardens, Glasnevin.

Roche, J., Mitchell, F.J.G. and Waldren, S. (2009). Plant community ecology of *Pinus sylvestris*, an extirpated species reintroduced to Ireland. *Biodiversity and Conservation* 18: 2185-2203.

Roe, O., and Merne O.J. (2006). *The Ecology of Blackrock. An Ecological Survey of Blackrock. Co. Louth*. A report prepared for Louth County Council.

RPS (2008). *Survey and mapping of habitats from Cratloe to Parteen, South-east Clare. Survey findings report*. Report prepared for Clare County Council.

Ryle, T., Murray, A., Connolly, C. and Swann, M. (2009). *Coastal Monitoring Project 2004-2006*. Report prepared for National Parks and Wildlife Service.

Scannell, M.J.P. and Synnott, D. (1987). *Census Catalogue of the Flora of Ireland*. 2nd edn. Stationery Office, Dublin.

Schouten, M.G.C. (1984). Some aspects of the ecogeographical gradient in the Irish ombrotrophic bogs. *Proceedings of the 7th International Peat Congress* 1: 414-432.

Scott Wilson (2008). *County Clare Habitat Survey – Survey of Natural Habitats in East County Clare*. Report prepared for Clare County Council.

Sheehy Skeffington, M., Moran, J., O'Connor, Á., Regan, E., Coxon, C.E., Scott, N.E., and Gormally, M. (2006). Turloughs – Ireland's unique wetland habitat. *Biological Conservation* 133: 265-290.

Smal, C. (1995). *The Badger and Habitat Survey of Ireland*. Report prepared for NPWS.

Smith, G.F., Delaney, E., O'Hora, K. and O'Donoghue, P. (2008). *Mayo Habitat Mapping 2008*. Report prepared for Mayo County Council. Atkins, Dublin.

Stokes, K., O'Neill, K. and McDonald, R.A. (2004). *Invasive Species in Ireland*. Report prepared for Quercus, Queens University, Belfast.

Tubridy, M. and Associates (2004). *Dublin Parks Management Study. Management plan for 5 parks in Dublin city (Bushy, Le Fanu, Springdale, St. Anne's and St. Kevin's)*. Report prepared for Dublin City Council.

Tubridy, M. and Associates (2005). *Laois Habitat Survey – Stage I*. A report prepared for Laois County Council.

Tubridy, M. and Associates (2006). *Laois Habitat Survey – Stage II*. A report prepared for Laois County Council.

Tubridy, M. and Associates (2007). *Laois Habitat Survey – Stage III*. A report prepared for Laois County Council.

Tubridy, M. and Associates (2008). *Laois Habitat Survey – Stage IV*. A report prepared for Laois County Council.

Tubridy, M. and Meehan, R. (2006). *Study to establish the extent, location of eskers and associated habitats in County Westmeath: Phase 2*. A report prepared as part of the Westmeath Heritage Plan.

Tubridy, M. and O'Riain, G. (2006). *Habitat survey of high biodiversity value areas in Dublin City, 2006*. Final report. A report prepared for Dublin City Council.

Tubridy, M. & Associates (2007). *River Dodder Habitat Management Plan 2007*. A report prepared for Dublin City Council.

Tubridy, M. (2006). *County Offaly Esker Survey 2006*. Report prepared for Offaly County Council.

White, J. and Doyle, G. J. (1982). The vegetation of Ireland: a catalogue raisonné. *Journal of Life Sciences, Royal Dublin Society* 3: 289-368.

White Young Green (2005). *Local area plans of 16 towns in County Kilkenny (Knocktopher, Slieverue, Freshford, Mullinavat, Stoneyford, Goresbridge, Ballyragget, Urlingford, Kells, Ballyhale, Fiddown, Gowran, Inistioge, Lough Macask, Mooncoin and Piltown)*. A report prepared for Kilkenny County Council.

Wilson, F., Goodbody, R. and Nairn, R. (2004). *Dublin City Graveyards Study*. Report prepared for Dublin City Council.

Botanical References

Higher plant nomenclature reference: Stace, C.A. (2010). *New Flora of the British Isles*. 3rd edition. Cambridge University Press, Cambridge.

Moss nomenclature reference: Smith, A.J.E. (2004). *The Moss Flora of Britain and Ireland.* 2nd edition. Cambridge University Press, Cambridge.

APPENDIX D SOURCES OF HABITAT INFORMATION AND OTHER REFERENCES

Liverwort nomenclature reference: Paton, J.A. (1999). *The Liverwort Flora of the British Isles*. Harley Books, Colchester.

Census lists, updated nomenclature and English and Irish names: National Botanic Gardens (2009). *Resources for Studying the Irish Flora*. http://www.botanicgardens.ie/herb/census/resource.htm. Accessed 15/01/10.

Some useful plant identification guides (list not comprehensive)

Atherton, I., Bosanquet, S. and Lawley, M. (editors) (2010). *Mosses and Liverworts of Britain and Ireland: A Field Guide*. British Bryological Society.

Blamey, M., Fitter, R. and Fitter, A. (2003). *Wild Flowers of Britain and Ireland*. A. & C. Black, London.

Curtis, T. and Thompson, R. (2009). *The Orchids of Ireland*. National Museums Northern Ireland, Holywood.

Dobson, F.S. (2000). *Lichens: an Illustrated Guide to British and Irish Species*. 4th edn. Richmond Publishing, Slough.

Hill M.O, Hodgetts N.G. and Payne A.G. (1992). *Sphagnum: A Field Guide*. Joint Nature Conservation Committee, Peterborough.

Hubbard, C.E. (1984). *Grasses: A Guide to their Structure, Identification, Uses and Distribution in the British Isles*. 3rd edn. Penguin Books, London.

Merryweather, J. and Hill, M. (1995). *The Fern Guide*. Backhuys, Leiden.

Poland, J. and Clement, J. (2009). *The Vegetative Key to the British Flora*. John Poland and Botanical Society of the British Isles.

Rich, T.C.G. and Jermy, A.C. (1998). *Plant Crib 1998*. Botanical Society of the British Isles, London. http://www.bsbi.org.uk/html/plant_crib.html. Accessed 04/09/09.

Rose, F. and O'Reilly, C. (2006). *The Wild Flower Key*. Frederick Warne, London.

Sayers, B. and Sex, S. (2008). *Ireland's Wild Orchids: A Field Guide*. Brendan Sayers and Susan Sex, Portmarnock. http://www.orchidireland.ie/. Accessed 04/09/09.

Stace. C.A. (1999). *Field Flora of the British Isles*. Cambridge University Press, Cambridge.

Webb, D.A., Parnell, J. and Doogue, D. (1996). *An Irish Flora*. Dundalgan Press, Dundalk.

The Botanical Society of the British Isles (BSBI) publish a series of handbooks that are highly useful for identifying difficult groups of plants, including: sedges, umbellifers, docks and knotweeds, willows and poplars, charophytes, crucifers, roses, pondweeds, dandelions, water starworts, fumitories and grasses.

APPENDIX E ACTIVITIES INFLUENCING THE CONSERVATION STATUS OF SITES

The European Commission has prepared a list of threats, pressures and activities influencing the conservation status of Natura 2000 sites, as used in their monitoring under Article 17 of the Habitats Directive. This list is revised on a semi-regular basis and was being updated as this publication was being finalised. As such, please go to the following website to download the most uptodate available version:

http://circa.europa.eu/Public/irc/env/monnat/library?l=/expert_reporting/work-package_revision/sub-group_papers/pressures_-threats/

APPENDIX F
SAMPLE FIELD DATASHEET

HABITAT SURVEY

Hab No.	Notes	Species

HABITAT SURVEY

Preliminary Habitat Map No. Weather / Survey Constraints:	Surveyor	Date

Hab No.	Data Method	Fossitt Code	Annex 1 Code	Listed SPP?	Evaluation	Condition	Threats	Photo I.D.

Data Quality: V = simple validation in field (+/- remotely) S = survey - walkover
Annex I Code: code as per interpretation manual
Listed Spp?: Protected or red data species at global, European or national level. Y or N and name under Species on back
Evaluation: I = International N = National R = Regionally important HL = High Local LL = Low Local O = Negligible
Condition: Ordinal Scale: 1 = very poor, 2 = poor, 3 = moderate, 4 = good, 5 = very good
Threats: Threats to habitats of HL or greater value. Code as per Natura 2000 activities codes and detail Notes on back

APPENDIX G METADATA HEADINGS FOR HABITAT SURVEY DATA

Fields	Description	Mandatory Under INSPIRE
Title	Title of the dataset	Y
Abstract	A brief abstract of the contents of the data, origins, methods, specifications, etc.	Y
Resource Type	Identifies whether spatial data resource is a dataset, a dataset series or a data service	Y
Resource locator	URL link to dataset or additional information on the dataset	Y (if available)
Unique Resource Identifier	A value uniquely identifying the resource, such as the filename	Y
Topic Category	Subject of data according to defined classification scheme in INSPIRE implementing rules. Categories for habitat data will be biota and environment and possibly others depending on the project	Y
Dataset Language	Language(s) used in dataset	Y
Keywords	Keywords describing the data for use in automated searches	Y
Software Format	Format and version number of the dataset software	
Related Datasets	Names of other datasets from the same habitat survey project	
Related Documents	Names of documents related to the dataset, particularly the habitat survey report	
Distributor Name	Name of the person(s) managing and distributing the data	
Distributor Organisation	Organisation managing and distributing the data	Y[16]
Distributor Address	Address of the person(s) managing and distributing the data	
Distributor Phone	Phone number of the person(s) managing and distributing the data	
Distributor Email	Email of the person(s) managing and distributing the data	Y
Creator Name	Name of the person(s) who created the data	
Creator Organisation	Name of the organisation that created the data	Y
Creator Address	Address of the person(s) who created the data	
Creator Phone	Phone number of the person(s) who created the data	
Creator Email	Email of the person(s) who created the data	Y
Coordinate Reference System	Coordinate reference system of the data	
Geographic Boundary North	Northern boundary (in appropriate coordinate reference system) of the dataset extent[17]	Y
Geographic Boundary East	Eastern boundary (in appropriate coordinate reference system) of the dataset extent[17]	Y
Geographic Boundary South	Southern boundary (in appropriate coordinate reference system) of the dataset extent[17]	Y

[16] Under INSPIRE implementing rules, the name of the organisation responsible for establishment, management and distribution of the dataset, the role of the responsible party (e.g. owner, distributor, originator), and contact email must be provided.

[17] Please note, that for INSPIRE purposes, the Geographic boundary box must be provided in latitude and longitude, however for practical purposes ideally ITM or IG coordinates should also be provided.

APPENDIX G METADATA HEADINGS FOR HABITAT SURVEY DATA

Fields	Description	Mandatory Under INSPIRE
Geographic Boundary West	Western boundary (in appropriate coordinate reference system) of the dataset extent[17]	Y
Date Begun	Commencement date of the habitat survey project	Y
Date End	End date of the habitat survey project	Y
Date Created	Date the dataset was created	Y
Date of Last Revision	Date the dataset was last revised	Y
Lineage	Overview of the history and processes involved in creating the dataset, including data sources, methodology and quality assurance procedures	Y
Base Mapping	Base mapping used for creating the habitat map	
Data Sources	The main GIS and non-GIS data sources used to inform the habitat dataset. Extensive lists of literature or consultees can be provided by cross-reference to survey report	
Thematic Accuracy	Estimate of accuracy of attribute information, sources of error and quality assurance	
Positional Accuracy	Estimate of positional accuracy, sources of error and spatial resolution	Y (spatial resolution)
Completeness	Evaluation of dataset completeness and reasons for gaps	
Conformity	Degree of conformity with INSPIRE implementing rules	Y
Conditions for Access	Conditions or limitations to accessing the dataset and reasons for these	Y
Attribute Fields	Comprehensive description of attribute headers and values attribute data can take, including definitions of codes used	
Metadata Contact	Name of the person(s) who created the metadata	Y
Metadata Organisation	Organisation that created the metadata	Y
Metadata Email	Email of the person(s) who created the metadata	Y
Metadata Date	Date the metadata were last revised	Y
Metadata Language	Language(s) used in metadata	Y

Published by The Heritage Council
Designed by Zinc
Editorial Consultant: Roberta Reeners
ISBN: 978-1-9-06304-14-o

An Chomhairle Oidhreachta
The Heritage Council

The Heritage Council
Church Lane, Kilkenny, Ireland.

T. +353 (0)56 777 0 777
F. +353 (0)56 777 0 788
E. mail@heritagecouncil.ie
www.heritagecouncil.ie

Atkins, Unit 2B, 2200 Cork Airport Business Park, Cork