Natural England Commissioned Report NECR013

Scientific research into the effects of access on nature conservation: Part 2: access on bicycle and horseback

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Introduction

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

This report is a supplement for England to the *Wildlife and Access Advisory Group Guidance 2001* (Penny Anderson Associates, 2001).

It includes all research undertaken between 2001 and 2008 and should be used in tandem with the 2001 report. Together they are a collation of all available scientific research relating to the effects of access on foot on habitats and species up to 2008. All research up to 2008 into the effects of access by bicycle or on horseback is also included.

The aim is to provide a scientific tool to help identify the potential impacts of access to enable measures to be put in place to secure the reconciliation of both access and nature conservation objectives.

The findings are now being published so that they can be used by authorities responsible for implementing new access projects or managing existing access and assessing the likely effects.

The information is intended to contribute to decisions and judgements made as part of an overall assessment process, but may also be used by conservation organisations and land managers who are considering the need to apply for, or remove, statutory exclusions or restrictions.

The information is also relevant to organisations and people managing access on land which is subject to:

- A statutory right of access.
- A right of access under an access agreement.
- Existing de facto access.

By identifying and protecting sensitive features from the effects of human interference, people's access to the natural environment can be promoted with the confidence that it is only being limited on nature conservation grounds where this is shown to be necessary. As such it will help Natural England deliver our policy on Inspiring People to Value and Conserve the Natural Environment through access to places where they can enjoy a high quality natural environment.

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Further information
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SCIENTIFIC RESEARCH INTO THE EFFECTS OF ACCESS ON NATURE CONSERVATION: PART 2: ACCESS ON BICYCLE AND HORSEBACK

Natural England Contract No. NPR06/01/003

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This report is a collation of available scientific research into the effects of access on nature conservation. The purpose of this report is to provide a scientific tool to help identify potential impacts of access and to enable measures to be put in place to secure the reconciliation of both access and nature conservation objectives. It will ensure sensitive features are identified and protected from the effects of human interference, so that people's enjoyment of the natural environment can be promoted with the confidence that it is only being limited on nature conservation grounds where this is shown to be necessary. As such it will help Natural England deliver its policy on Inspiring People to Value and Conserve the Natural Environment through access to places where they can enjoy a high quality natural environment.

This report is a supplement for England to the Wildlife and Access Advisory Group Guidance 2001 (Penny Anderson Associates, 2001). This report includes all research undertaken between 2001 and 2008 and should be used in tandem with the 2001 report. Together they are a collation of all available scientific research relating to the effects of access on foot on habitats and species up to 2008. All research up to 2008 into the effects of access by bicycle or on horseback is also included.

The Wildlife and Access Advisory Group (WAAG) Guidance was produced in 2001 by English Nature (now Natural England) and the Countryside Council for Wales, with endorsement from the Countryside Agency, RSPB and others in response to the Countryside and Rights of Way Act 2000. It was used successfully to undertake appropriate assessments throughout the implementation of CRoW open access in England and Wales.

The research summarised in this report may be used by Relevant Authorities[1] and others in conjunction with knowledge of local circumstances including likely levels of use and a detailed knowledge of local conditions. It is intended to contribute to decisions and judgements which are made on a site by site basis as part of the overall assessment process. This report aims to ensure that any action to control or manage access is based on a scientifically reasoned argument, drawing on available knowledge. It provides a consistent approach when utilised in different areas or counties.

The Guidance may also be used by:

- Conservation Organisations and land managers considering whether there may be a case for statutory exclusions or restrictions under relevant legislation, or for the need for action to circumvent such exclusions or restrictions, and
- Any organisation or person considering the need to manage access on land which is subject to:
    - A statutory right of access including those granted under enactments such as the Countryside and Rights of Way Act, the Law of Property Act 1925, the Commons Act 1899, or local or private Acts.
    - A right of access under an access agreement (eg. Pt V of the National Parks and Access to the Countryside Act 1949).
    - Existing de facto access.

The Guidance does not provide prescriptive solutions to perceived problems, but identifies those circumstances where nature conservation interests may trigger consideration of appropriate action on sites. The nature of that action, including whether it will require any statutory exclusion or restriction, can only be determined by analysis at the site level.

The scope of this Guidance is on direct nature conservation implications arising from access. There may be indirect effects linked to a statutory right of access, such as risks associated with fire or safety hazards, but these are not covered in detail in this Guidance.

The main authors are Footprint Ecology's James Lowen, Durwyn Liley, John Underhill-Day and Andrew Whitehouse of Buglife.

[1] Relevant authorities are responsible for administering restrictions on CRoW access land

Natural England's viewpoint

This Guidance has a wide application across all access projects in Natural England, but is specifically relevant to the need for appropriate assessments in relation to access on Natura 2000 sites.

Summary

This report updates original guidance on the nature conservation impacts of access that was published in 2001. This original guidance focused on access on foot only and focused on the habitats associated with the access element of the Countryside and Rights of Way (CRoW) Act (2000).

This update is broader in scope than the original and encompasses a wider range of habitats (a range that now includes the full suite of coastal habitats) and also access by bicycle and on horse back. New chapters added to this report include saline lagoons, coastal grazing marsh, rocky shores, seals and a generic chapter on the impacts of cycling and horse riding.

We have attempted to retain the headings and style used in the original document, and it is intended that the two documents are used in tandem. As in the original, this report contains sections on habitats, species groups. Used together it is intended that these two documents provide a comprehensive overview of the potential nature conservation implications of recreational access to the English countryside.

Contents

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1. INTRODUCTION AND RATIONALE

1.1. This document acts as a supplement to the original Wildlife and Access Advisory Group Guidance (Penny Anderson Associates, 2001), written by various habitat and species specialists working for the then English Nature and Countryside Council for Wales. Rather than amend or add to the original text, this report should be used in tandem with the original.

Need for a supplementary guidance

1.2. The Countryside and Rights of Way Act 2000 (CRoW) incorporates rights of access on foot in England and Wales, for open air recreation, to mountain, moor, heath, down, and registered common land. The introduction of open access has not been without controversy. During the passage of the bill, a Wildlife and Access Advisory Group (WAAG) was established with membership drawn from the statutory agencies and voluntary conservation organisations to provide advice on how to reconcile potentially conflicting requirements (Bathe, 2007). This group's main task was the preparation of guidance documentation enabling site managers to identify circumstances in which access management measures might be necessary. The resulting guidance material (Penny Anderson Associates, 2001), hereafter referred to as "the original guidance" covers different species and habitat groups, based on the available literature and expert opinion at the time. It was recognised that there were a number of gaps in the understanding of the impacts of access, particularly with respect to disturbance to birds. The group was therefore also involved in commissioning a programme of research to improve the knowledge base underpinning the guidance (Langston et al., 2007a). The programme of research was carefully prioritised (e.g. Liley, 2001). Much of the research has now been completed and a series of publications now results from the research programme. This has largely been collated in various sources, most notably the proceedings of the BOU Disturbance Conference held in 2006 (see Drewitt, 2007), and also in a variety of other sources (Langston et al., 2007a; Liley, 2007).

1.3. Since implementation of the CRoW access rights was completed in 2005, Natural England has considered further improvements to public access to the countryside. Projects currently in hand include realising the benefits of access provided under historic legislation (as listed at CRoW Section 15), often including 'higher rights' and also enhancing access to the coast. Enhancement to coastal access will take place within the Marine Bill With the aim to integrate access with the conservation of a dynamic coast to achieve "a coastal environment where rights to walk along the length of the English Coast lie within a wildlife and landscape corridor that offers enjoyment, understanding of the natural environment and a high quality experience; and is managed sustainably in the context of a changing coastline".

What the guidance covers

1.4. This supplementary guidance should be used in tandem with the original guidance, and includes new material relating to the following areas:

1.5. **Update of the original guidance** for the period 2001 – 2008. We have generally used the same chapter headings as the original guidance. For each chapter we provide a summary of the new material and a detailed review of work published since the original guidance. We have broadened the scope of the wooded commons chapter, extending this to include all woodland.

1.6. **Impacts from horse riding and cycling**. We provide a single chapter reviewing the impacts of these two activities, and material specific to particular groups or habitats covered in the original guidance is also included in the relevant chapters.

1.7. **Coastal Habitats**: given the high profile of coastal access we have enhanced the coastal chapter and included new sections to cover key species (such as seals) and additional habitats (such as saline lagoons).

1.8. We limit our scope to include access on foot, horse or bicycle, including people accessing the coast from the water and those accessing boats and other craft from the land. Climbing, coasteering and other coastal sports are included where material exists, but are not a primary focus for the document. We only include habitats and species that occur above mean low water, and do not include impacts from boats (such as wave action, noise, pollution from paints, fuel spillages etc). We include all coastal habitats, including estuaries. We do include direct habitat loss (for example as a result of new car parks or access facilities), hunting, conflicts between user groups and the guidance does not address mechanisms or solutions for reconciling access and nature conservation.

Methods

1.9. Our approach has been to use the headings and structure of the original guidance (allowing the potential to merge the two documents at a later date). The original document was however specific to CRoW and it has been necessary to modify the structure in a number of places. Changes of note are:

- A new chapter on horse riding and cycling.
- A series of new chapter headings for coastal habitats. We have also retained the generic coastal habitats chapter heading used in the original guidance.
- A new heading in most chapters entitled “implications of research”. This new chapter fits alongside the CRoW specific chapter on statutory exclusions or restrictions and allows us to highlight any broader access management issues (i.e. beyond CRoW) highlighted in the new research.
- A new chapter summarising gaps in our understanding and areas for further research.
- The Birds chapter we have restructured. Due to the large volume of new material for this group it was felt necessary to adjust the structure and we have used habitat headings to allow easy cross-referencing with other chapters.

1.10. The literature review was conducted using the Endnote (version X2) as a central database. Searches (and access to literature) were made using various web based search engines and databases including JSTOR, Synergy, Web of Science, Conservationevidence.com and Google Scholar. An initial trawl of the literature was made using habitat search terms (mountain, moor, coast, heath, wood, fens, lowland grassland), each paired with each of the following impact terms: trampling, human disturbance, visitor access, horse riding, cycling, mountain bike and recreation. Searches were focused on literature post 2001 and on those that related to the UK or Europe, but studies from outside the UK were included where relevant.

1.11. The results of this initial trawl were combined with existing reference lists held by the authors, and subsets of references generated for each habitat and issue. These lists were then sent to Natural England habitat specialists as a check for additional material. The Natural England library catalogue was also searched, and all new material was added to the database. UK BAP priority species and habitat plans were also checked to identify species and habitats where access, disturbance, and development infrastructure were identified as current threat. Development infrastructure was included as development can result in an increase in people living nearby and therefore increased access levels. Housing brings higher numbers of people to given areas (Liley and Clarke, 2003; Liley et al., 2006b). Species vulnerable to coastal erosion may include species associated with bare ground and habitats where access / trampling could be issues. Species experts, site managers, academics and other nature conservation practitioners were contacted where additional material or expertise was required or for copies of unpublished material / manuscripts in prep. All people contacted are given in the acknowledgements.

1.12. In terms of nature conservation impacts, the crucial understanding is the impact of the access at a population scale, the extent to which the access is having an impact on the population size of the species studied. Unfortunately this is often very difficult, requiring an understanding of the population dynamics of the species being studied, and very few studies succeed in placing impacts of access in a population context (see Gill et al., 2001b;Sutherland and Norris, 2002 for further discussion; Sutherland, 2007). There is therefore a very large volume of literature on access and its impacts, but much of it is of limited use in an applied context, such as identifying when access is a problem. We focus on the studies which have direct, applied relevance, and highlight other studies where they suggest a population impact or issue that may have population consequences.

Who the guidance is aimed at

1.13. The guidance provides an overview of current understanding of access impacts and highlights gaps where future research should be targeted. It is intended to be used by those responsible for access policy, those assessing impacts of access and those implementing access at a local level. We hope that it will be used by site managers, access officers, conservation officers and policy makers.

2. THE GENERIC EFFECTS OF HORSE RIDING AND CYCLING ON NATURE CONSERVATION

Summary

- There is relatively little information on the impacts of horse riding and cycling. Most studies have taken place in the USA or Australia, and much of the focus is on damage to tracks.

- There is clear evidence for damage (including erosion, path widening and soil compaction) to paths and tracks from both types of use. Damage from horses can be especially severe, due to the high ground pressure. Damage from mountain bikes is potentially similar in intensity to that of pedestrians, but differs in nature, often creating narrow ruts. Damage from both types of activity depends on a variety of factors such as the nature of the soil, slope angle, and wetness.

- For both types of activity, damage can occur at low rates of use, but additional increases in use do not lead to a proportional increase in track damage. Damage to tracks and paths can cause conflict between users and be costly to repair.

- Both types of activity may have disturbance effects. Where cyclists and horse riders dismount then the impacts will be the same as people on foot. There are very few studies that directly compare horse riders or cyclists to other types of user, and little can be concluded from the limited results.

- Both types of activity have been associated with causing direct mortality of ground nesting birds and sand lizards and their eggs. There are relatively few examples of loss of birds' nests, and this is unlikely to be a major impact, especially if bikes and cyclists stay on existing tracks. There are accounts of incidents where horse and mountain bikes have caused damage to reptile foci, the frequency with which this occurs, the extent of the damage and the scale of the impact in terms of population impacts are not known. There are also accounts that reveal direct damage to invertebrate habitat on paths resulting from horse riding.

- Species that use tracks and track edges are clearly likely to be be vulnerable, but the evidence is largely anecdotal and no studies have tried to quantify the links between track damage from horses or bikes and loss of habitat for key species.

Introduction

2.1. The original guidance addressed only the impacts of access on foot. This chapter provides an overview of access for horse riding and cycling. We focus on documenting how these two activities may have additional, or different, impacts to access solely on foot. For both activities, riders can be accompanied by dogs, however we do not directly consider the impacts of dogs within the chapter.

2.2. In this chapter we include the impacts of horse riding, addressing recreational riding, sometimes described as hacking, and long-distance riding / trekking. We do not include horse drawn vehicles, fox or drag hunting. Estimates of the number of horse riders in the UK range from 1.3 million people (Newsome *et al.*, 2004) to 2.4 million (Penny Anderson Associates, 2006). There are some data on numbers associated with particular sites. For example, there are some 2,700 horses estimated to be owned by people living within and adjacent to the New Forest National Park (England Marketing, 2005). The proportion of riders is often small compared to other types of visitor. In Exmoor National Park riders account for 7% of visitors (Crowe and Mulder, 2004). By contrast horse riders comprise 3% of those to Dartmoor National Park (Dartmoor National Park Authority, 2004), 2% of visitors to the Thames Basin Heaths SPA (Liley et al., 2006c), and 1% of those to the Dorset Heaths SPA (Clarke *et al.*, 2006), and New Forest National Park (Tourism South East Research Services and Geoff Broom Associates, 2005),

2.3. By cycling we refer to the use of pedal bikes rather than motor bikes, scramble bikes or trail bikes. Cycling encompasses mountain biking along designated routes, events and family outings. We do not specifically address the impacts of the construction of trails, jumps or circuits for bikes, activities often associated with children on urban sites (e.g. Underhill-Day, 2005). Compared to horse riding recreational cycling in the countryside, off-road, is a relatively new phenomenon. Mountain bikes were first produced in 1979 in America and the first imports occurred in the UK in 1982 (Palmer, 2006). Membership of different clubs and levels of use are summarised in Penny Anderson Associates (2006). Cyclists make up a relatively small proportion of visitors to different sites, for example 8% of visitors to the Peak District National Park (Crowe and Mulder, 2004) are cyclists, 7% of those to the Broads National Park (Crowe and Mulder, 2004), 6% of those to the Thames Basin Heaths SPA (Liley et al., 2006c) and 2% of visitors to the Dorset Heaths SPA (Clarke *et al.*, 2006). Studies that have addressed choice of site have shown a preference by mountain bikers for sites with rough terrain, steep slopes and water stations (Symmonds et al., 2000; Goeft and Alder, 2001).

Overview of impacts

2.4. There are a number of general reviews that address the nature conservation impacts of horse riding (Liddle, 1997; see Landsberg et al., 2001; Liley et al., 2002; Newsome et al., 2002; Newsome et al., 2004; Penny Anderson Associates, 2006; Newsome et al., 2008). Fewer reviews exist for cycling (but see Cessford, 1995; Liddle, 1997; Liley et al., 2002; Penny Anderson Associates, 2006; Marion and Wimpey, 2007). We draw largely on these reviews and supplement them with specific studies where relevant. For cycling we draw on some work that is based on motorbikes, as the impacts may be similar. For both horse riding and cycling much of the literature is from Australia or the USA and there is little available information for impacts specifically within the UK.

2.5. The impacts of horse riding or cycling will be dependent upon a range of factors (see Figure 1), many of which will be specific to a site or location. To understand the total impact it is necessary to draw on social research of visitor behaviour and choice of site, visitor surveys describing the routes taken and direction travelled by different users, their group size and frequency of visit, as well as ecological research on the different impacts to species and habitats.   In order to address the population consequences of the total impact, data from a number years are likely to be necessary in order to develop an understanding of the population dynamics of the study species (e.g. Liley and Sutherland, 2007; Mallord et al., 2007d). Few studies reach this level of detail and the focus of most access research is simply on damage to site infrastructure

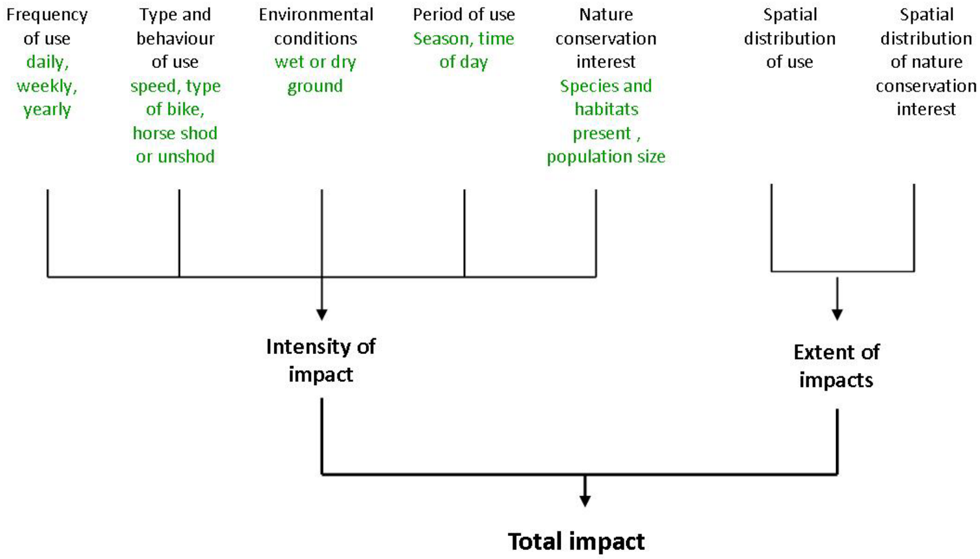

Figure 1: Elements that might determine the scale of impact resulting from horse riding or cycling. Green text gives examples of different elements. Adapted and modified from Roovers (2005).

2.6. Following the definitions presented in Liddle (1997), the potential impacts of recreational pursuits can be split into three broad categories, and we use these to structure this chapter, considering horse riding and cycling in turn:

- Behavioural response to disturbance: the most obvious form of potential impact, involving only animals. In this case, the animal is aware of the presence of the person, but there is no physical contact. The behaviour of the animal may change as a result – for example a bird being flushed from a feeding site or nest.
- Habitat alteration: where the habitat is changed as a result of the recreational activity, for example erosion of paths. Vegetation cover and erosion are closely linked and therefore we consider vegetation impacts in this chapter.

- Direct mortality: where a damaging and direct contact occurs, for example treading on the nest of a ground nesting bird.

Horse Riding

Behavioural response to disturbance

2.7. There are a wide variety of studies, especially with respect to birds, which describe disturbance effects (for reviews see Hill et al., 1997 ;Nisbet, 2000;Woodfield and Langston, 2004a). These studies demonstrate a range of different impacts in different circumstances to different species. In general, the presence of people can cause changes in feeding behaviour (e.g. Burger, 1991;Fitzpatrick and Bouchez, 1998;Verhulst et al., 2001;Thomas et al., 2003a) or cause birds to take flight (e.g. Stalmaster and Kaiser, 1997;Burger, 1998;Fernandez-Juricic et al., 2001;Blumstein, 2003;Blumstein et al., 2003 ;Fernandez-Juricic et al., 2005;Webb and Blumstein, 2005). Physiological impacts may occur, such as changes in the levels of stress hormones (Remage-Healey and Romero, 2000; Tempel and Gutierrez, 2003; Walker et al., 2006) or heart rate (Nimon et al., 1996; Weimerskirch et al., 2002). Very few studies directly address horse riding specifically, or compare horse riding with other types of access. None of the published reviews of the impacts of horse riding (Landsberg et al., 2001; Newsome et al., 2002; Newsome et al., 2004; Newsome et al., 2008) mention disturbance impacts.

2.8. Through direct observation of elk *Cervus canadensis*, Naylor (2006), found no difference in the distance at which elk fled from different sources of disturbance, including all terrain vehicles (ATVs), horse riders, cyclists and hikers. However, activity monitors attached to the elk showed that there was little or no reduction in the time spent feeding or resting when the disturbance was from horse riders. This contrasted with the other types of disturbance, especially the ATVs.

2.9. There is conflicting evidence on the disturbance effects of horses on birds. Snowy plovers are more likely to fly from horses than people (Lafferty, 2002). In contrast Burger (1986) suggests people on horseback did not seem to threaten birds, even though horse riders frequently moved rapidly. Burger, herself a horse rider, surmised that the birds perceived only the horse and not the person riding. In their work on disturbance to wintering waterfowl on estuaries in part of Suffolk, Ravenscroft *et al.* (2008) described horse riding as relatively “benign”, but did not specifically separate horse riders from other types of users.

2.10. Liddle (1997), in a subjective classification of different recreational activities and their likelihood to disturb birds or animals, scored different activities on a scale of 1 (low effect) to 5 (high effect). Horse riding was given a score of 3, ranking the activity on a par with sailing, hang gliding, and downhill skiing.

Habitat Alteration

2.11. Newsome *et al.* (2008) recognise a number of different impacts to habitats, summarised in Table 1

Table 1: Impacts to habitats and or vegetation resulting from horse-riding in natural areas. Adapted from Newsome *et al.* (2008).

Impact	*Significance*	*Possible nature conservation / management implications*
Soil		
Soil erosion	Soil and nutrient loss, water turbidity, sedimentation, alteration of water runoff	Aesthetic impact for other users, impaired access for other users, health and safety risk, creation of bare ground habitats
Soil compaction	Reduced infiltration, reduced germination, reduced vigour and growth of certain plant species	Aesthetic impact for other users, nature conservation impacts if plants are limited in distribution / important.
Churning and lifting of surface soil particles	Accelerated erosion rates	Aesthetic impact for other users, creation of areas of soft substrates. .
	Changes in soil depth.	Implications for invertebrates, plants and herptiles associated with bare ground
Water movement		
Reduced water infiltration rates	Strong contributor to tread widening and multiple trail creation as users seek to circumvent muddy sections of trails.	Aesthetic impact for other users. Additional paths and path widening can have consequences.
Increased surface run-off	Accelerated erosion rates.	Aesthetic impact for other visitors.
Vegetation		
Trampling and loss of vegetative cover	Vegetation loss, replacement by trampling resistant species, increased amount of bare ground, reduced vegetation height.	Aesthetic impact for other users. Loss of vegetated habitats and increase in bare ground a problem on some sites.
Alteration of plant species composition	Species that are less tolerant to trampling or associated with nutrient-poor soils are replaced by species that are more resistant to trampling or more competitively dominant in more nutrient enriched conditions (nutrient enrichment through dung).	Nature conservation impacts where rare or important plant species or communities present. Aesthetic impact for other users.
Tree damage and root exposure	Root damage, reduced tree health, intolerance to drought.	Aesthetic impact for other users, health and safety consequences, damage to trees.
Plant defoliation through grazing	Reduction in plant vigour, damage to aerial parts of some plants thereby reducing flowering ability and hence reproductive success.	Most sites of nature conservation importance already grazed.
Structural changes to trail		
Increased trail width	Vegetation loss, increased amount of bare ground.	Aesthetic impact for other users. Increased area of bare ground a problem on some sites.
Informal and multiple trail development	Vegetation loss, wildlife habitat fragmentation.	Increased area of bare ground a problem on some sites.
Introduction of foreign material		
Manure on trails	Introduction of weed species	Aesthetic impact for other users.

Spread of plant disease	Vegetation loss, reduction in plant vigour.	Aesthetic impact for other users, restriction of access due to quarantine areas.

2.12. The consequences of recreational activity on soil characteristics are complicated and the subject of a considerable volume of work (e.g. Cole, 1987;Liddle, 1997;Growcock, 2005;Komatsu et al., 2007). In general, trampling causes compaction and the maceration and physical removal of litter from the path surface as well as a reduction in the depth of the organic soil layers. This will also lead to a reduction of porosity, as does the direct force of compaction. The reduction in porosity means that there is less space for air and water, and a subsequent reduction in the suitability of the soil to support living processes. The physical action of feet or wheels may also loosen or displace some particles, and this together with the reduction in plant cover, leads to soil erosion. This can be accentuated by the fact that rainfall cannot easily penetrate the compacted soil and hence a greater proportion flows over the soil surface.

2.13. Erosion will also occur both during and after recreational activity (e.g. Kuss, 1983). The maximum impact force of a galloping horse's hoof is 8.89kN on hard soil (Frederick and Henderson, 1970, quoted in Liddle 1981) and the ground pressure of a horse's hoof when a rider is on its back may be as much as 27 times that of a walkers shoe (Liddle, 1997). This pressure may be greater than that from a four-wheel drive vehicle with four passengers (Table 2).

Table 2: Total weight, area in contact with the ground, and calculated stationary pressure exerted on the ground in association with a range of outdoor recreational activities. Adapted from Liddle (1997)

Source of pressure	Average weight (kg)	Contact area (cm^2)	Static pressure ($g\ cm^2$)
Man wearing boots	**80**	**388**	**206**
Woman wearing boots	**57**	**356**	**160**
Unshod horse and rider	**613**	**478**	**1282**
Shod horse and rider	**613**	**140**	**4380**
Motorbike (Trail bike)	**229**	**114**	**2008**
Four-wheel-drive Toyota, empty	**2 100**	**1355**	**1550**
Four-wheel-drive Toyota, with four people and gear	**2 500**	**1483**	**1686**

2.14. The impacts to tracks caused by horse-riding may therefore far exceed other users such as cyclists or walkers (Dale and Weaver, 1974;Wilson and Seney, 1994;Deluca et al., 1998;Newsome et al., 2004). Tracks used by horses are likely to be wider, deeper and muddier (Newsome *et al.*, 2004).

2.15. Horses' hooves dig into the surface, both pushing particles horizontally and, particularly on clay soils, causing compaction. Detached soil particles are then vulnerable to runoff, especially on slopes (Weaver and Dale, 1978;Wilson and Seney, 1994;Siikamäki et al., 2006) and where vegetation is not present (Liddle, 1997). On slopes, the direction of travel, (upslope or downslope) can be important, with damage greater when travelling downslope due to the 'halting action' used downhill (Weaver and Dale, 1978). Impacts are also likely to be most severe where horses are allowed to stray off trails and / or in environments prone to waterlogging (Landsberg *et al.*, 2001).

2.16. Detailed monitoring of paths in D'Entrecasteaux National Park, Western Australia was conducted by Newsome and Philips (see Newsome et al., 2002). The relative frequency of plant species, percentage vegetation cover, vegetation height and soil depth were recorded along experimental transects subject to trampling intensities of 0, 20, 100, 200 and 300 passes by a horse and rider. Horse riding changed the relative frequency of plant species by causing a decline in the native herbaceous plants and the percentage of bare ground increased from 5.2% (0 passes) to 31% (300 passes). There was also a rapid reduction in percentage vegetation cover following 20 and then 100 passes. The greatest amount of decrease in vegetation cover was 34% between 20 and 100 horse passes with the most significant rate of decrease (15.4%) in the percentage of vegetation cover occurring between 0 and 20 horse passes. The greatest amount of change in vegetation height (56.5 mm) occurred between 0 and 20 passes, the level of intensity that also produced the greatest reduction in soil depth (8.1mm). This work was conducted in Australia, and it is not known to what extent such results are applicable in different countries, however do provide evidence that horse riding impacts can occur at relatively low intensities of use.

2.17. Trampling causes damage to and loss of plant parts, and the effects on and responses by individual plant species will differ, for example heather may be more damaged by trampling than purple moor-grass (Lake et al. 2001). The impact of wear is least in the growing season (Liddle 1997). Compared to human access on foot, horses create between 1.7 and 4.4 times more bare ground (Liddle, 1997). Impacts vary according to habitat. For example, erosion caused by horse riders on forested trails in Finland (Siikamäki *et al.*, 2006) was lowest in the driest forest type with a lichen-rich ground flora, compared to forest with a dry heath understorey or moist forest characterized by a bog myrtle dominated groundflora.

2.18. The presence of horses may also affect soils in other ways besides trampling. Liddle and Chitty (1981) compared soils from paths and areas away from paths at Chobham Common, a heathland site in Surrey. The paths were well used by horse riders. Path soils tended to have higher nutrient contents than untrampled soils and their fertility was higher in relation to adjacent areas. The authors suggest that this may be due to dung deposited from horses, whose food is grown outside the heathland ecosystem.

2.19. Horse droppings can also serve to distribute seeds. Weaver and Adams (1996, cited in Landsberg 2001) recorded 29 plant species germinating from horse manure samples collected from horse trails in three national parks in Australia. An experimental study by Finnish researchers found that a number of introduced species were able to establish themselves in study plots treated with horse manure. Moreover, there was an interaction between horse manure treatment and humus removal treatment indicating that the non-native species were more likely to establish themselves in protected areas when the vegetation and soils are prone to trampling disturbance either by horses, hikers or other users. There is a lack of evidence on the extent to which horse droppings act as a dispersal vector for seeds within the UK. Lake (2002) found no evidence of seedlings germinating from pony dung on several lowland heathland sites grazed by ponies in southern England.

2.20. An additional impact of recreational horse riding is grazing (see Newsome *et al.*, 2004). Grazing impacts are only to be expected where horses are tethered or fenced over night, as happens on long distance trails where riders camp. Such riding is rare in the UK.

2.21. Habitat alteration therefore occurs primarily through trampling, which can result in a reduction in vegetation height, change in species composition and an increase in the area of bare ground. Tracks used by riders are likely to be wider, muddier and deeper than those used by other users. These impacts are likely to have consequences for the nature conservation interest of sites that support species associated with bare ground and/or where path edges are an important habitat feature. This issue is discussed further in the heathland chapter (see paras 3.11 - 3.13) and detailed examples are provided in the invertebrate chapter (see paras 22.8 - 22.16).

Direct mortality

2.22. There is little direct evidence of direct mortality through trampling as a result of horse riding. Trampling by grazing livestock, particularly cattle, is a well documented cause of nest loss for many ground nesting birds (Jensen et al., 1990;Hart et al., 2002;Wilson et al., 2004b;Watson et al., 2006). There are few examples of nest trampling by horses, most of it anecdotal (see Penny Anderson Associates, 2006), but it can occur. For example, of the 20 American oystercatcher nest failures documented by Sabine *et al.* (Sabine *et al.*, 2006) using nest cameras, one nest was trampled by a horse. Of the 47 nightjar nests monitored by Murison on heaths in Dorset (Murison, 2002), one was trampled by a horse. In neither case is it known whether the horse was being ridden or not.

2.23. Reptile foci have been shown to be vulnerable to trampling. Sand lizards lay their eggs in burrows dug by the females in unshaded, bare sand, a habitat that, on many sites, may only be available along paths and tracks (Edgar, 2002). The nests are situated at a depth of only four to ten cm below ground level and Edgar documents a number of examples where nests and adult females have been trampled by horses (see also the Herptile chapter, para 21.15).

2.24. There are also examples of damage to invertebrate burrows on heathland tracks (see the Invertebrate chapter, paras 22.14 - 22.15) for more details).

Cycling

Behavioural response to disturbance

2.25. As with horse riding (see 2.7) very little of the extensive literature devoted to disturbance effects specifically address cycling. However, the general disturbance literature is relevant as cyclists do not always remain on their bikes while in the countryside, and some studies (e.g. Van der Zande et al., 1984;Gill et al., 1996;Rees et al., 2005;Liley et al., 2006a;Liley and Sutherland, 2007;Summers et al., 2007) simply group all disturbance events together, whether cyclists, walkers or others. In this chapter we specifically address disturbance from people on bicycles. Only three studies exist, all on large mammals.

2.26. An experimental study in Switzerland evaluated the disturbance associated with hiking, jogging, and mountain biking on high elevation chamois (Gander and Ingold, 1997). The authors assessed alert distance, flight distance, and distance fled, and found that approximately 20 percent of the animals fled from pastures in response to visitor intrusions. The alert and escape distances of chamois were influenced both by time of day and mode of travel along a trail through their habitat. Late in the morning, the disturbance response of chamois to joggers and mountain bikers was slightly stronger than their response to hikers. The authors suggest the faster pace of the joggers and cyclists may have posed an increased threat to the chamois.

2.27. Taylor and Knight (2003) investigated the interactions of wildlife and trail users (hikers and mountain bikers) at Antelope Island State Park in Utah. A hidden observer using an optical rangefinder recorded bison, mule deer, and pronghorn antelope response to an assistant who hiked or biked a section of trail. The observer then measured wildlife reactions, including alert distance, flight response, flight distance, distance fled, and distance from trail. Observations revealed that 70 percent of animals located within 330 feet (100 m) of a trail were likely to flee when a trail user passed, and that wildlife exhibited statistically similar responses to mountain biking and hiking. While Taylor and Knight found no biological justification for managing mountain biking any differently than hiking, they note that bikers cover more ground in a given time period than hikers and thus can potentially disturb more wildlife per unit time.

2.28. In the above two studies all users remained on the trail. By contrast, a study of big horn sheep in the US evaluated the behavioural responses of the sheep to disturbance by hikers, mountain bikers, and vehicles in low- and high-use areas of Canyonlands National Park (Papouchis *et al.*, 2001). Sheep fled 61 percent of the time from hikers, 17 percent of the time from vehicles, and six percent of the time from mountain bikers. The stronger reaction to hikers, particularly in the high-use area, was attributed to more off-trail hiking and direct approaches to the sheep.

2.29. In their study of wintering waterfowl in two estuaries in Suffolk, Ravenscroft *et al.* (2008) recorded a behavioural response from birds for just over 20% of the instances that cycling was observed. This was broadly similar to the percentage of times walkers, walkers with dogs and joggers caused disturbance

Habitat Alteration

2.30. Wheels exert compactive and shearing forces on surfaces and a downward pressure through the tyres. Bike tyres create linear channels that may promote runoff and erosion, and most studies focus on these physical impacts of mountain biking. A range of studies clearly demonstrate that bikes cause incisions (Goeft and Alder, 2001;White et al., 2006), soil compaction (Bjorkman, 1996;Goeft and Alder, 2001), erosion (Wilson and Seney, 1994;Bjorkman, 1996;Goeft and Alder, 2001;Marion, 2006) and reduce vegetation cover (Goeft and Alder, 2001;Thurston and Reader, 2001).

2.31. Marion (2006) studied 47 segments of track in the southwest USA, measuring soil loss along transects across the track to evaluate the influence of use-related, environmental, and management factors. Tracks that contoured around slopes were significantly less eroded than trails in valley bottom positions, in part due to the influence of periodic floods. Erosion rates on tracks with 0-6 percent and 7-15 percent slope angles were similar, while erosion on trails with gradients greater than 16 percent was significantly higher.

2.32. Bjorkman (1996) evaluated two new mountain biking trails in Wisconsin before and for several years after they were opened to use. Vegetation cover within the tread declined with increasing use to negligible levels while trailside vegetation remained constant or increased in areas damaged by the initial construction of the trail. Similarly, soil compaction within the tread rose steadily while compaction of trailside soils remained constant. Vegetation and soil impacts occurred predominantly during the first year of use with minor changes thereafter.

2.33. Spatially, the impact of mountain bikes can be quite limited. For example one study showed that, after a maximum of 500 passes, visible impact from mountain bikes was concentrated within a narrow zone no greater than 30 cm from the track centreline (Thurston and Reader, 2001), suggesting that cyclists tend to steer a similar course. Where cyclists are in groups – such as families – this may of course not be the case as they may ride side by side.

2.34. The contact pressure (the mass divided by the contact area) of a bike is likely to be less than that of motorised vehicles, horses and heavily laden walkers (see Cessford, 1995). Comparative research on track impacts by

Weaver and Dale (1978) found that motorbikes (the study did not include cyclists) had the greatest effects while going uphill, but that when going downhill, the effects of horses and walkers were greater. The reduction in cover of grassland vegetation caused by mountain bikes is estimated to be twice that caused by walkers and approximately half that caused by horse riders. Compared to human access on foot, motor-bikes create between one and 16.6 times more bare ground (Liddle, 1997). Wilson and Seney (1994) identified a similar pattern, but showed that lighter and low-powered bikes had less track impact potential than motorbikes.

2.35. In a study in the USA (White *et al.*, 2006), the extent and severity of damage to trails varied between regions. The authors suggest environmental features such as soil type and vegetation cover, variations in the intensity of use and user behaviour as possible explanations. Damage increased with slope at three of the five regions.

2.36. A number of studies show that the short-term impacts of mountain biking and hiking (when compared at similar intensities of use) may not differ greatly (Thurston and Reader, 2001;White et al., 2006). The immediate impacts of both activities can be severe but rapid recovery should be expected when the activities are not allowed to continue.

2.37. While track damage has consequences for other users and management of the site it is difficult to link such damage to nature conservation. Where there are key species associated with bare ground or track sides then cycling may be an issue. For example; Edgar (2002) describes tracks at Canford Heath, Dorset as rendered unsuitable for sand lizards due to the activity of cyclists. This issue is discussed further in the heathland chapter (see para 3.13).

Direct mortality

2.38. There are few recorded instances of nests of ground nesting birds being crushed by cyclists. Although at least one of 269 ringed plover nests monitored at Snettisham, North Norfolk between 1996 and 1998 was crushed by a bicycle (Liley, 1999), it would seem such instances are rare. Few ground nesting birds nest on tracks and most select taller vegetation (e.g. Mallord *et al.*, 2007b) or are on beach habitats such as shingle where it is expected that the number of cyclists will be low.

2.39. There are case studies where mountain bikes have been suspected to have caused damage to reptile sites and killed adult sand lizards and their eggs (see case studies for Canford Heath, Parley Common and Town Common in Edgar, 2002). In most cases horse riding is also cited as occurring on the same tracks and in these cases the horse riding appears to be the main cause of fatality.

Implications of research

2.40. Evidence for disturbance effects of both horse riding and cycling is limited and in places contradictory. Studies either group several types of disturbance together and/or consider only behavioural responses (for example, the distance at which animals flee). Given these limitations, and the difficulty in drawing any useful conclusions from behavioural studies (see Gill et al., 2001b;Beale and Monaghan, 2004a;Gill, 2007), little can be concluded at this point in time. Disturbance effects may be different for horse riding and cycling, and in the absence of detailed studies, it cannot be ascertained whether either are likely to cause a greater or lesser impact than people on foot.

2.41. In general disturbance effects are most likely to impact on birds, although some effects may also impact on mammals, herptiles and invertebrates. Species most likely to be vulnerable are those tied to a particular location (for example a nest site) or associated with specific habitats where these are particularly favoured for the activities themselves (e.g. tracks). Certain times of year (for example the breeding season) are likely to be more stressful than others.

2.42. Most horse riding and cycling takes place on tracks, although off track-use can be high in some places, for example 38% of horse riders in the New Forest stray off existing tracks (England Marketing, 2005). Once tracks are established, whether by formal or informal means, there are four main interrelated management problems arising from the ongoing trampling. These are: (i) Excessive erosion from enhanced water flows and disturbed soil surfaces on sloping sections of track, or at drainage points across the track; (ii) muddy stretches in water-saturated sections of tracks, often including major soil structure disruption and leading to the widening of tracks; (iii) development of multiple parallel tracks where the main track is harder to traverse than the adjacent surfaces (e.g. more rocky, muddy, wet etc.); and (iv) development of informal tracks, including shortcuts on corners and around focal sites such as viewpoints.

2.43. With both cycling and horse riding, the scale of damage is likely to be linked to the surface material of the track, slope angle, degree of waterlogging, speed of travel and the behaviour of the rider. Slopes and water features will attract riders wanting a particular experience – and such riders may well be more likely to ride faster.

2.44. There may be interactions with other recreational users which may result in the scale of impact from horse riding or cycling. While mountain bikers and, to a lesser extent, horse riders are likely to stay on tracks, their presence could have an indirect effect on neighbouring vegetation by dint of trail erosion or deconditioning (e.g. muddying), that makes walkers feel forced to head off-path, consequently trampling potentially sensitive vegetation. In addition, some types of users, such as dog walkers, will actively select sites not used by horse riders or cyclists (e.g. Edwards and Knight, 2006), potentially resulting in knock-on consequences at other sites.

2.45. Where use is confined to tracks then a nature conservation impact will occur where key species are present on those tracks or where management resources are drawn away from nature conservation management. The nature conservation interest can be affected both through direct mortality and through habitat change. Erosion is not necessarily a problem, and in some circumstances may actually be beneficial, creating bare ground and early successional habitats. Many plants are only associated with such habitats and various reptiles and invertebrates require bare ground at various stages in their life cycles. Some kind of physical disturbance is usually required to create the bare ground habitats, and hence a certain level of physical disturbance can be beneficial. However, the level of disturbance required is difficult to define and is likely to vary between sites (Lake *et al.*, 2001). Species associated with loose and uncompacted bare ground may be particularly vulnerable. Further discussion of this issue is provided in the heathlands chapter (see para 3.24) and detailed examples relating to invertebrates and reptiles can be found in the relevant chapters.

3. LOWLAND HEATHLAND

Summary

- Concern about the cumulative effects of development, leading to increased visitor pressure and urban effects, have led to a variety of studies exploring the links between access, housing and nature conservation impacts. These studies reveal high levels of visitor pressure on many lowland heathland sites and show clear links between the number of visitors and the amount of housing surrounding sites.

- A series of studies of trampling effects to heathland vegetation in Brittany have shown differences between plant species and according to time of year.

- Bare ground habitats within heathlands are very important for nature conservation and on many sites access is likely to be the principal mechanism by which the area of bare ground is maintained.

- There is a large volume of work on disturbance to heathland birds, showing clear effects to Annex I bird populations. There is also new material relating to invertebrates and reptiles. These studies are discussed in the relavent taxa chapters.

Introduction and Context

3.1. Lowland heathland is one of the habitats included as open country within the CRoW Act (2000). The original guidance (chapter 4) includes an extensive body of material on lowland heathland. Relevant material published since the original guidance includes new material on heathland birds and disturbance and on the impacts of new housing around heathland sites, highlighting the impacts of new development on European Protected sites and species. There is also a body of work from Brittany, exploring the impacts of trampling and there is new material relating to the impacts of access to reptiles.

3.2. We summarise this new material, and also extend the scope of the coverage to include Maritime Heath, which was omitted from the original. Maritime Heaths are exceptional among heathland habitats in that they can be considered as climatic climax community (Rodwell, 1991). Occuring on cliff tops and exposed sections of coast, the habitat often contains coastal species such as spring squill *Scilla verna* (see H7 description in Rodwell, 1991 for full description).

Accessibility of Sites with Heathlands

3.3. There have been a number of visitor studies addressing visitor behaviour, access patterns and use of heathland sites (Atlantic Consultants, 2003;W.S.P. Environmental, 2004;Atlantic Consultants, 2005;Tourism South East Research Services and Geoff Broom Associates, 2005;Clarke et al., 2006;Liley et al., 2006c;Liley et al., 2006g;Underhill-Day and Liley, 2007). These studies have been targeted at sites of nature conservation importance and in some cases the visitor data subsequently used to explore nature conservation impacts (Liley et al., 2006a;Clarke et al., 2008a;Sharp et al., 2008).

3.4. The visitor studies typically show high levels of recreation. The cumulative effects of new development in the vicinity of heathlands, resulting in an increase in recreational pressure and other urban effects, has become a key issue for the habitat (Haskins, 2000a;Underhill-Day, 2005;Liley et al., 2006b). These issues are particularly crucial to heathlands as many areas of lowland heathland are in southern England and close to large conurbations. The visitor studies reveal a wide range of different recreational uses, with dog walking typically the most common reason for visiting, for example accounting for 59% of groups on the Thames Basin Heaths SPA (Liley et al., 2006c).

3.5. Predictive models showing the spatial distribution of visitors across different heathland SPAs have allowed predictions for total visitor numbers and highlight the large proportion of some SPAs networks that are visited by people (Liley et al., 2006a;Liley et al., 2006b;Sharp et al., 2008). For example estimates for the number of person visits, per year, to the Dorset Heaths are in the region of 5 million and the Thames Basin Heaths possibly as many as 10 million (Liley et al., 2006a) The New Forest National Park is estimated to receive over 13 million (Tourism South East Research Services and Geoff Broom Associates, 2005;Sharp et al., 2008)

General Vulnerability of Sites with Heathland to Direct Impacts arising from Access

3.6. Different types of heathland (and different species) are susceptible to different levels of trampling. On English heaths, heather *Calluna vulgaris* has been found to be more damaged by trampling than purple moor-grass *Molinia caerulea* (Lake *et al.*, 2001). Assessments of the impact of heathland trampling in north-west France demonstrated that mesophilous heathlands (characterized by Dorset heath *Erica ciliaris*) tended to be more sensitive to trampling than dry heathlands. However, the resistance of these communities and their component species varied greatly in relation to season and weather conditions (Gallet and Roze, 2001). Dry and mesophilous heathlands are both more tolerant to trampling in winter than in summer. In the case of mesophilous heathland, this is linked to high plant resilience, especially of Dorset heath (Gallet and Roze, 2002). This species was more tolerant in wet conditions than dry (Gallet and Roze, 2002). In summer, bell heather *Erica cinerea* was more sensitive to trampling in wet weather than dry (Gallet and Roze, 2001). Heather species were more sensitive than the rest of the plant cover (Gallet and Roze, 2001).

3.7. Repeated trampling affects the recovery rate of different heather species in different ways (Gallet *et al.*, 2004). The impact on Dorset heath was the same at any trampling rate between one and five passes, whereas for bell heather and western gorse *Ulex gallii*, trampling was slightly less damaging when applied once compared to five times. Dorset heath is thought to have a lower resistance and higher recovery capacity. Recalling the findings of Growcock (2005) on alpine and subalpine vegetation in Australia, a primary threshold for heather vegetation was 20–40 passes, which increased sensitivity to disturbance. Another threshold was passed between 200–400 passes, leading to a new level of degradation (Gallet *et al.*, 2004).

3.8. Comparative research in central Belgium determined that the (dry) heathland community was less sensitive to trampling than mesophilous forest communities as a result of being dominated by more resistant graminoids (purple moor-grass *Molinia caerulea*, wavy hair-grass *Deschampsia flexuosa*) and dwarf-shrub species (bilberry *Vaccinium myrtillus,* heather *Calluna vulgaris,* cross-leaved heath *Erica tetralix*), but recovered more slowly (Roovers *et al.*, 2004).

3.9. There is very little published information on access impacts to maritime heaths. One of the key areas of maritime heath in the UK is on the Lizard, where increasing visitor pressure, particularly on sections of the long distance Coast Path and around 'honeypot' car parks, has led to local erosion, trampling of vegetation, fire damage and disturbance by humans and dogs (Tonkin *et al.*, 1997). Paths and tracks on the Lizard are of particular importance for scarce plant species (see para 23.16).

3.10. Dune heath is a rare habitat that occurs on mature, stable dunes where the initial calcium carbonate content of the dune sand is low. The habitat type (Atlantic decalcified fixed dunes *Calluno-Ulicetea***)** is listed under Annex I of the Habitats Directive, and is limited in England to a small number of sites such as Studland (Dorset), Winterton (Norfolk) and the Drigg coast in Cumbria. We address access impacts to this habitat within the dune chapter (chapter 14).

3.11. Bare ground and early successional habitats are a very important component of the heathland ecosystem, important for a suite of plants, invertebrates and reptiles (Byfield and Pearman, 1996;Lake and Day, 1999;Moulton and Corbett, 1999;Key, 2000;Kirby, 2001). On the Dorset Heaths it is bare ground habitats, rather than heather dominated ones, that support the most rare species (Key, 2000) and of the 90 BAP species associated with lowland heathland, 39% depend on bare ground and early successional habitats (Alonso *pers. comm.*). Many plants are only associated with such habitats (e.g. tiny annuals such as slender centaury *Cicendia filiformis*, coral necklace *Illecebrum verticillatum*, mossy stonecrop *Crassula tillae* and pygmy rush *Juncus pygmaeus*). Mossy stonecrop is associated with bare, sandy soil and slender centaury and coral necklace with wetter hollows, even vehicle ruts and hoof prints (Lake *et al.*, 2001). Paths that are of high value to invertebrates (therefore those where there may be concern about access levels being too high) are unshaded, with a sunny aspect, open to the south, sloping and sheltered from the wind (see Symes *et al.*, 2003).

3.12. Some kind of physical disturbance is usually required to create these bare ground habitats, and hence a certain level of physical disturbance can be beneficial. Localised erosion, the creation of new routes and ground disturbance may all contribute to the maintainance of habitat diversity within sites. However, the level of disturbance required is difficult to define and is likely to vary between sites (Lake *et al.*, 2001). There are likely to be optimum levels of use that maintain the bare ground habitats but do not continually disturb the substrate, unfortunately such levels of use have never been quantified, nor is it known whether sporadic use is likely to be better at maintaining bare ground habitats than low level, continuous use.

3.13. Heavy use of sandy tracks, particularly by horses or mountain bikes, causes the sand to be loose and continually disturbed (see chapter 2), rendering the habitat of low value to many invertebrates (Symes *et al.*, 2003). Species which burrow into flat surfaces (i.e. the centres of paths) are likely to be particularly vulnerable, as loose sand may not support their burrows and the churning may make it impossible for them to relocate their burrows once dug. The friable nature of heathland soils makes them particularly vulnerable to these impacts. Management to contain any erosion problems, such as path surfacing, may make the habitat useless for invertebrates.

3.14. Many heathland areas are adjacent to large urban conurbations. Parts of the Dorset Heaths fall within Poole and Bournemouth, part of the Thames Basin Heaths are adjacent to M25 London orbital, the New Forest is adjacent to Southampton. For many heathland sites access impacts, such as trampling and erosion, are just part of a suite of impacts relating to the urban environment (Haskins, 2000a;Underhill-Day, 2005;Liley et al., 2006b). The number of visitors is related to the number of houses surrounding sites (Liley et al., 2006a;Liley et al., 2006b;Dolman et al., 2008), and it is difficult to disentangle the effects of access from the other urban impacts. The amount of housing surrounding sites, or visitor numbers, are significant predictors of the numbers of certain birds present on sites (Liley and Clarke, 2003;Mallord, 2005;Clarke et al., 2008b). Housing levels surrounding sites also show clear correlations with fire incidence on sites (Kirby and Tantrum, 1999). Urban impacts, in particular the need to ensure that the conservation interest of sites is not damaged by increased housing pressure, are likely to be a long term issue for heathland conservation in the UK.

3.15. An additional potential impact from horse riding is nutrient enrichment of heavily used tracks, which may lead to a change in plant species composition (Liddle and Chitty, 1981;Liley et al., 2002).

Types of Site with Lowland Heathland with Particular Vulnerability to Access Related Issues

3.16. Recent research does not contradict the assertion in the original guidance (see para 4.4.1) that the most sensitive communities in heathland are lichen-rich heathland and *Sphagnum*/wet heath. Valley mires in lowland heathlands contain sphagnum moss communities and species such as bog orchid *Hammarbya paludosa*, which are known to be vulnerable to trampling (Lake *et al.*, 2001).

3.17. On wet heath areas, the ground is likely to be particularly vulnerable to trampling. Such conditions are beneficial to certain species, but the individual plants themselves may suffer. For example pale butterwort *Pinguicula lusitanica* may require some physical disturbance to create suitable germination niches (Lake, 2002). Limited physical disturbance may therefore not be a problem, especially during the winter months. Species associated with wet heath are likely to be vulnerable only when the habitat is continuously trampled or when the intensity of use is particularly high (Liley *et al.*, 2002).

3.18. The Breck heaths of Norfolk and Suffolk are characterised by a high cover of lichen species, including several of conservation concern, and trampling may be a particular issue (see plant chapter, para 23.31). The finest terricolous lichen communities in Breckland are limited to two trackways where it is thought that pressure from the human foot is beneficial as it compresses the substrate, but there is concern about other types of use, especially in the winter when heavy episodic use can churn the ground up (Gilbert, 2002). Some Breckland sites also support stone curlews for which access can be an issue (see birds chapter, paras 19.32 - 19.35).

3.19. Heathland sites with open access and that are surrounded by high human populations are likely to be under particular pressure.

Associated Interests

3.20. New information relevant to the impact of trampling on heathland fauna is covered in the respective chapters of this report. Disturbance to birds is a key issue on heathlands and there have been a large number of studies published since the original guidance, addressing disturbance impacts to stone curlews (see paras 19.32 - 19.35), nightjars (see paras 19.36 - 19.40), woodlarks (see paras 19.41 - 19.44) and Dartford warblers (see paras 19.45 - 19.47). There is also new material on the impact of disturbance to reptiles (see chapter 21), invertebrates (see paras 22.9 - 22.18) and plants (see paras 23.16 - 23.19) associated with heathland.

3.21. Dune heath is a rare habitat and can support lichen rich heath. Trampling impacts to dune habitats are addressed in chapter 14. Issues relating to lichens are covered in the plant chapter (see paras 23.31 - 23.37).

Implications of research

3.22. In the light of experimental trampling of Atlantic heathlands in north-west France, researchers advise that management of tourist pressure on natural or semi-natural sites should take visitors to the more tolerant communities. Accordingly, site managers are advised to take into account the variability of tolerance to trampling of the different types of vegetation present and needs to be adaptable to environmental conditions (Gallet and Roze, 2002). The finding that a single event of high-level trampling is not more damaging than regular trampling over time (and, indeed, is less damaging for dry heathland species) suggests that site managers could consider opening vulnerable areas of a site only for a particular event as an alternative or complement to regular use (Gallet *et al.*, 2004).

3.23. Work in Belgium showed that the proliferation of heathland walking routes could lead to a large affected area with an extended recovery requirement (Roovers *et al.*, 2004). It took at least two years until heathland sites subjected to experimental trampling had entirely recovered. Researchers thus recommended that management plans should discourage off-path hiking by providing effective visitor guidance, sufficient high-quality visitor infrastructure and influencing the spatial distribution of visitors.

3.24. Bearing in mind that bare ground and early successional habitats are a very important component of the heathland ecosystem, the optimum management strategy for most sites may be to maintain a varied vegetation and habitat structure which includes a range of different bare ground types. To be assessed as in favourable condition heathland SSSIs should contain this mosaic of different habitat strucutre. The appropriate intensity of use will vary between sites, according to soils, terrain, water levels, frequency of flooding and existing management. High-intensity use should, however, be avoided. Most heathland managers aim to maintain a mosaic of different habitats within a site so some sites or parts of sites may benefit from an increased level of physical disturbance; others, however, would not. Access arrangements need be considered on a site-by-site basis (Liley *et al.*, 2002).

3.25. Careful planning and site assessment should enable site managers to assess current access levels, conduct a risk assessment and identify pinch points where access could compromise conservation interest features. Significant statutory exclusions and restrictions are likely to be necessary for direct conservation reasons (Liley *et al.*, 2002) only where:

- access demand and wear is likely to be unusually high due to the proximity of major populations and the lack of alternative sites;

- there are specialised and fragile heathland vegetation categories, especially lichen heath, dune heath and wet heath and where these are vulnerable to damaging levels of pressure; or

- there are vulnerable species interests.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

3.26. Statutory exclusion is justified between March and August on sites where stone curlews are present (see the birds chapter, paras 19.32 - 19.35).

3.27. Restrictions to keep dogs on leads are justified where Annex I breeding birds occur (nightjar, woodlark and Dartford warbler), see the birds chapter, (19.27 - 19.48) for more details. Breeding commences in March for woodlark (April for Dartford warblers and May for nightjars) and continues into August (nightjars).

Related Concerns

3.28. Reviews of urban impacts highlight the range of issues on heathland sites in urban areas (Haskins, 2000b;Underhill-Day, 2005;Liley et al., 2006b), with impacts such as dog fouling, increased fire risk, alien species, fly tipping, erosion and vandalism all linked to increased urban development surrounding heathland sites. Many of these impacts are related to high public pressure and access. Dog fouling is addressed in the grassland chapter (see paras 7.10 - 7.11 and chapter 4.3.8) in the original guidance.

3.29. Path surfacing to divert people along particular routes or contain access problems such as erosion can often be disastrous for invertebrates (S. Miles *pers. comm.*). Surfacing with gravel, hoggin, chips or similar material can entomb invertebrates within their burrows and can render the path useless in the future as the invertebrates can no longer burrow through the capping (see paras 22.65 and 22.66)..

3.30. Dog fouling is potentially an issue in this habitat, see the grassland chapter (paras 7.10 - 7.11).

Opportunities Associated with a Statutory Right of Access

3.31. No new information.

4. MOUNTAIN AND MOOR

Summary

- Some useful information has been published since 2001 on the impact of disturbance on mountain and moorland habitats. Resurfacing of a Pennine Way path has enabled a doubling in visitor numbers *and* benefits for two species of upland breeding waders. Trampling has a moderate impact on most alpine and subalpine vegetation communities, but recovery times are long. Habitats have different thresholds to damage, and low trampling levels can exact large impacts in particularly sensitive communities, such as blanket mires.
- Cliff faces and crags are sites of high and specialised biodiversity, and the distinct vegetation subcommunities that exist on cliff faces correlate with fine scale differences in microtopography. Cliff faces are subject to rock climbing (not covered in the orginal guidance). Climbed cliff faces tend to support a lower mean richness of vascular plants and bryophytes and different frequencies of individual species compared to pristine cliff faces.
- Mountain biking and horse riding may pose additional pressure on montane or moorland habitats susceptible to trampling and erosion. Horse riding is more likely to have a greater impact than mountain biking, due to the greater pressure imposed by the former and the greater likelihood of cyclists to stay on trails.

Introduction and context

4.1. No relevant new information has been published since the original guidance (chapter 5.1).

Accessibility of Sites with Mountain and Moor

4.2. No relevant new information has been published since the 2001 guidance (chapter 5.2).

General Vulnerability of Sites with Mountain and Moor to Direct Impacts arising from Access

On and off path use

4.3. On the Pennine Way, the path resurfacing reported in the original guidance (see para 5.3.2) has been successful in keeping walkers on the track rather than on nearby vegetation. In turn, this has benefited two species of upland breeding wader (golden plover *Pluvialis apricaria* and dunlin *Calidris alba*). When 30% of walkers strayed from an unsurfaced and poorly maintained Pennine Way footpath, the movement of people across the moorland was widespread and unpredictable. In consequence, golden plovers avoided areas within 200 m of the footpath during the chick-rearing period. However, once the footpath was surfaced, only 4% of walkers strayed from the path, meaning that golden plovers only avoided areas within 50 m of the footpath (Finney *et al.*, 2005). Meanwhile, dunlins showed a non-significant increase of 50% in habitat utilisation following provision of a surfaced footpath (Pearce-Higgins *et al.*, 2007).

4.4. This reduced rate of wader–habitat avoidance occurred despite a doubling in visitor numbers (Pearce-Higgins and Yalden, 1997;Finney et al., 2005). Resurfacing of the path thus significantly reduced the impact of recreational disturbance on upland wader distribution, showing that implementation of simple measures to influence visitor behaviour (e.g. a well-surfaced route) can dramatically reduce the impact of recreational disturbance on wild animal populations while enabling access by large numbers of visitors (Finney et al., 2005;Pearce-Higgins et al., 2007).

Increases in path networks and width

4.5. No new information.

Numbers of visitors and activities

4.6. Given the current interest in higher rights activities, we provide some limited information published recently on cycling and horse riding in English uplands. We also summarise likely impacts on montane and moorland vegetation but caution that there have been no direct studies on the impact of these activities in these habitats.

4.7. The proportion of visitors to sites that come to ride their horses varies but is often quite small. The proportion of horse riders is high in Exmoor National Park, with riders accounting for 7% of visitors (Crowe and Mulder, 2004). By contrast horse riders comprise 3% of those to nearby Dartmoor National Park (Dartmoor National Park Authority, 2004). Cyclists make up a relatively small proportion of visitors to different sites, for example 8% of visitors to the Peak District National Park (Crowe and Mulder, 2004) are cyclists, a slightly higher proportion than lowland national parks. Studies that have addressed choice of site have shown a preference by mountain bikers for sites with rough terrain, steep slopes and water stations (Symmonds et al., 2000;Goeft and Alder, 2001).

4.8. A mindboggling, but nevertheless potent higher rights threat is posed by the annual World mountain bike bog snorkelling championships, which take place on private land in the uplands at Waen Rhydd near Llanwrtyd Wells in Wales

4.9. [1]. A trench 40 m long and 1.8 m deep is cut in a bog; competitors have to cycle two lengths of the bog underwater, using snorkels and specially prepared mountain bikes that have weighted tyres. Two other events also take place here: the World bog snorkelling championship and the Bog snorkelling triathlon, where the activities are similar but without mountain bikes; separate trenches (shallower but longer than for the mountain bike event) appear to be dug for this annual event. While the impacts of these sporting activities have not been assessed, substantial damage is inevitable in terms of bog removal (cutting the trench) and trampling (by feet and mountain bike). We are unclear on whether bog snorkelling takes place elsewhere in Wales or in England and the extent to which participation is increasing.

[1] see http://llanwrtyd-wells.powys.org.uk/bog.html

4.10. Tourism is increasing in most mountain areas in Europe (Zaghi, 2008). In the EC report on management of alpine and boreal heath the main impacts to this Annex I habitat from recreational activities relate to hiking, skiing, motor bikes and all-terrain vehicles (ATVs) and tourism development (Zaghi, 2008)

Sensitivity of plant species

4.11. There is a small body of recent evidence relating to the sensitivity of particular montane habitats, particularly alpine and subalpine vegetation, cliff faces and blanket mires. We summarise this here.

4.12. An experiment investigated the impact of trampling on six vegetation types representative of cryptogam–vascular plant communities in the Cairngorm Mountains of Scotland. Trampling progressively destroyed the structure of the vegetation of all communities and increased evapotranspiration rates. *Vaccinium/Hylocomium* heath communities had the greatest cumulative evapotranspiration and lichen heath the least. The grassland community vegetation was the most resilient to trampling (Growcock, 2005).

4.13. Some evidence from a study of the impact of recreational activity, specifically camping and trampling, on alpine and subalpine vegetation in Australia (Growcock, 2005) may be relevant to the UK situation. Low levels of recreation use were found not to cause significant damage to vegetation until a primary threshold is reached, whereafter increasing use results in rapidly increasing amounts of damage. A second threshold may then be found above which increasing use does not result in significantly more damage. Primary thresholds were exceeded after only moderate trampling, with damage still evident one year later. Fire made vegetation particularly susceptible for trampling damage (Growcock, 2005).

4.14. Experimental trials assessed the impact of recreational trampling in undisturbed alpine and sub-alpine vegetation communities in Tasmania (Monz, 2002). Although geographically distant from the UK and thus unlikely to be directly comparable, key findings may provide useful insights for site managers:

- Resilience differs between habitats. In sub-alpine buttongrass and alpine herbfield, prolonged and sustained damage may occur after 100 passes by walkers, after 200 passes in flat alpine herbfields, and 500 passes on cushions. Plant morphology was one determinant of resistance and resilience, with upright woody shrubs and tall tussock graminoids most vulnerable to sustained trampling damage;

- The full extent of damage was not apparent immediately: loss of vegetation cover peaked 6–12 months after trampling;

- Low trampling levels can have large impacts: pads formed with as few as 30–100 passes per annum and tracks form at between 100 and 500 passes per annum.

4.15. Although not directly relevant to England, a study of the impacts of trampling on dryas and tussock tundra plant communities in Alaska found that 500 passes resulted in a 50% cover loss in dryas and 70% cover loss in tussock, immediately after trampling, but that both communities showed a substantial capacity for regrowth. Tundra communities thus appear to be able to tolerate moderate levels of hiking, provided that use is maintained below (unspecified) disturbance thresholds and that visitors employ (unspecified) minimum-impact techniques (Kuntz and Larson, 2006b).

4.16. Cliff faces and crags have been recently recognised as being sites of high and specialised biodiversity, and the distinct vegetation subcommunities that exist on cliff faces correlate with fine scale differences in microtopography (Bragg and Tallis, 2001). This exacerbates the potential population effect of one specific recreational activity, namely rock climbing. Several recent studies demonstrate the potential impact of this activity on vulnerable cliff vegetation, albeit with neither consistent results for management conclusions. These are summarised in the section on *Sites with particular vulnerability to access-related issues* below.

4.17. British blanket mires have long been managed ecosystems (Bragg and Tallis, 2001), with a long tradition of vegetation manipulation for a variety of reasons (grazing, fuel extraction, water catchment, forestry, military training and recreation). Among the variety of impacts are changes in surface microtopography resulting from trampling. Compaction by trampling can also result in gully erosion by reducing permeability of the upper peat layer or acrotelm (Bragg and Tallis, 2001;Haigh, 2006), and in accelerated runoff (Haigh, 2006).

4.18. Bog communities in an alpine and subalpine area of Australia showed very low resistance to damage. Repeat trampling in the following year compounded the damage and lowered the primary threshold of vegetation resistance (Growcock, 2005).

4.19. Lakeside vegetation is sometimes susceptible. High mountain lakes have long been a magnet for recreational activity. At Peñalara Lake in central Spain, intensive tourist pressure since the 1970s has caused severe erosion of the shoreline (Toro and Granados, 2002). Two species of bryophyte that are associated with reservoir shores on Dartmoor have been identified as susceptible to recreational activities on the shores (see plant chapter, para 23.23).

Vegetation recovery

4.20. Once alpine and subalpine vegetation in Australia was damaged by trampling, it showed very limited ability to recover (Growcock, 2005). Another study confirmed that recovery times in these communities are slow (Whinam and Chilcott, 2002). Vegetation trampled 30–100 times per year for three years exhibited some small recovery after two years, but vegetation subjected to 500 passes showed no recovery after two years (Whinam and Chilcott, 2002).

4.21. Dryas and tussock tundra plant communities in Alaska subject to low or moderate trampling recovered fully within four years, but high levels of disturbance had longer-lasting effects (Monz, 2002).

4.22. A review of UK peat wetlands has suggested consideration of investment in the restoration of the most degraded areas, particularly those used for tourism or nature conservation (Haigh, 2006).

Other upland interest

4.23. Recent research concerning moorland and mountain fauna is contained in the relevant chapters. Of particular importance are the findings on upland breeding waders in the Birds chapter (see paras 19.49 - 19.53), summarised in the On and off path use section above (see paras 4.3 - 4.4).

Types of Site with Mountain and Moor with Particular Vulnerability to Access Related Issues

4.24. Rock climbing was not covered in the original guidance. Research on the impacts of rock climbing on cliff vegetation has produced varied results. Recent work in Canada is consistent with previous research in finding that sport-climbed cliff faces supported a lower mean richness of vascular plants and bryophytes and significantly different frequencies of individual species compared to pristine cliff faces (Kuntz and Larson, 2006a). Pristine cliff faces had nearly double the vascular plant richness of climbed faces. Species richness of bryophytes was a third lower, but lichen species richness little different (Kuntz and Larson, 2006a).

4.25. However, the differences were not related to climbing disturbance but rather to the climbers' selection of cliff faces with microsite characteristics that support less vegetation. Climbed sites had not diverged towards a separate vegetation community, but instead supported a subset of the species found on pristine cliff faces. Cliff features large enough to support vegetation in the absence of disturbance continue to support this vegetation even with climbing disturbance. However, the authors caution that the true impact of sport climbing may not be apparent for 7–12 years (Kuntz and Larson, 2006a).

4.26. Another study of Canadian cliff faces produced slightly different findings (McMillan and Larson, 2002). The density, percent cover, species richness, and species diversity of vascular plants were lower on climbed outcrops than on unclimbed outcrops. In addition, the proportion of alien plants was three times greater in climbed areas than in unclimbed areas. The frequency and richness of bryophyte species were also significantly lower in climbed areas. The frequency of lichens was the same on climbed and unclimbed cliffs, but species richness was significantly lower in climbed areas, and community composition differed between climbed and unclimbed areas (McMillan and Larson, 2002).

4.27. Two studies in Switzerland found that vascular plant cover and species density was significantly reduced at the base and on the face of cliffs subject to sport climbing (Müller et al., 2004;Rusterholz et al., 2004). Climbing also significantly altered plant composition and specialised rock species occurred less frequently on climbed cliffs than on unclimbed cliffs (Müller *et al.*, 2004). Shrub density decreased, but fern density tended to increase. In addition, rock climbing altered the proportions of different plant life forms (Rusterholz *et al.*, 2004).

4.28. It would seem that there can be clear impacts of rock climbing to the nature conservation interest of cliffs. The level of impact will depend on the nature conservation interest of the cliffs and potentially the intensity of use. It is perhaps new routes that are likely to be of most concern (see Penny Anderson Associates, 2006 for further discussion, including frequency with which rock climbers do seek new routes),

4.29. Given the high susceptibility of several types of montane and moorland habitat to trampling (see elsewhere in this chapter), such as blanket bog communities, it is likely that horse riding and mountain biking will present real, if localised, issues. This is particularly the case on steep slopes (Weaver and Dale, 1978) that are common in uplands; bike erosion rates are notably higher on gradients greater than 16% than gentler terrain (Marion, 2006). Mountain bikers are perhaps more likely to stick to moorland paths than horse riders, due to the difficulty in pedalling off-path and the impossibility of doing so through anything other than short vegetation. Mountain bike impact may thus be linear.

For horse riding, habitats prone to waterlogging are also vulnerable (Landsberg et al., 2001).

4.30. Upland heather moorland has decreased in cover in Scotland at least (Milne and Hartley, 2001). Although grazing herbivores are undoubtedly responsible for the bulk of nitrogen enrichment of upland heathlands, the risk is increased by recreational access visits with dogs or horses.

Associated Interests

4.31. Distubance issues to red deer are addressed in the mammals chapter (see paras 20.4 - 20.8). Disturbance to upland birds, including grouse, raptors and breeding waders, is covered in the birds chapter (chapter 19).

Implications of research

4.32. A study of alpine and subalpine vegetation in Australia have identified two thresholds of disturbance (Growcock, 2005), a finding that is thought to be beneficial for management decision making and may be applicable to English mountains. A primary threshold defines the upper limit of use for dispersed recreational use, while a secondary threshold will define when concentrated use should occur. This was thought of particular importance given the slow recovery of montane vegetation following trampling (Growcock, 2005). The use of particular thresholds has also been advocated in Alaska, where dryas and tussock tundra plant communities appear to be able to tolerate moderate levels of hiking, provided that use is maintained below disturbance thresholds and that visitors employ minimum-impact techniques (Monz, 2002).

4.33. This contradicted earlier research where rock climbing was thought to have significant negative effects on all aspects of the vegetative community on cliffs; in consequence, researchers recommended specific policies regarding recreational rock climbing for lands containing exposed cliffs, including bans in particular areas (McMillan and Larson, 2002). Research on Swiss cliffs similarly suggested that sport climbing significantly affected plant cover, species density and community composition and was thus considered a threat to sensitive plants of the limestone cliff community. The researchers considered that management plans and conservation actions were needed to preserve the threatened plant species on frequently climbed cliffs. Such plans should include the establishment of climbing-free protection areas on cliffs with a high number of specialized, relic plants and the protection of entire cliffs that are not yet climbed (Müller et al., 2004;Rusterholz et al., 2004). The recent suggestion that differences in cliff face vegetation were not related to climbing disturbance but rather to the climbers' selection of cliff faces with microsite characteristics that support less vegetation suggests that some caution is warranted before restrictive management practices are adopted.

4.34. Where vegetation has been damaged by trampling and has long recovery times, as with bog communities, repeat trampling in the following year has been found to compound the damage and lower the primary threshold of vegetation resistance (Growcock, 2005). This suggests that site managers might give consideration to management efforts to prevent repeat or continued trampling of sensitive vegetation that has already been damaged.

4.35. Given that alpine and subalpine vegetation in Australia has shown to be easily damaged by trampling (Growcock, 2005) and to have long recovery times (Whinam and Chilcott, 2002), researchers have suggested that concentrating walkers on the lowest possible number of sites may be the best management option (Whinam and Chilcott, 2002), a finding which may be worth considering with regards vulnerable upland vegetation with similar characteristics in England.

Circumstances in which Statutory Exclusion or Restriction of Access should be considered

4.36. The original guidance suggested that exclusions would be necessary only in exceptional circumstances. Restrictions (whereby visitors are confined to linear routes to avoid damaging the most sensitive areas including montane summits, wet heath, flushes, blanket bog, rocky slopes with skeletal soils, screes and certain calcareous grassland) were recommended only where management measures were difficult or impossible to achieve. The clear benefits of path resurfacing in the Pennines (see para 4.3 above), would suggest that the provision of clear pathways may be enough to confine where people walk, and if restrictions were in place to keep people to linear routes these may well be successful.

Related Concerns

4.37. Despite the existence of bye-laws on many sites excluding camping, wild camping might be expected on access land. Camping for three nights in Australian subalpine and alpine vegetation resulted in only a short-term decrease in dead vegetation, and camping for shorter periods had no significant impact (Growcock, 2005).

4.38. Dog fouling is potentially an issue in this habitat (see the grassland chapter, paras 7.10 - 7.11).

Opportunities Associated with a Statutory Right of Access

4.39. The growth in internet usage since the original guidance was published has stimulated considerable provision of web-based information to visitors, with national parks such as the Peak District developing informative and user-friendly websites.

5. LOWLAND RAISED BOG (Active and Degraded)

Summary

- There has been little material relevant to lowland raised bogs published since the original guidance, and thus little to add to the original guidance.
- Two studies have re-iterated the impact of trampling on bog surface microtopography and erosion.
- There are no studies addressing cycling or horse riding impacts to lowland raised bog.

Introduction and Context

5.1. No new information to complement the summary in the original guidance (chapter 7.1).

Accessibility of Sites with Raised Bog

5.2. No new information to complement the summary in the original guidance (chapter 7.2).

General Vulnerability of Sites with Raised Bog to Direct Impacts arising from Access

5.3. Recent research adds little to the assessment made in the original guidance (chapter 6.3). Interestingly, a recent overview of the status of the world's cool temperate bogs did not consider visitor disturbance to be one of the main direct anthropogenic threats to the habitat. Instead, peat harvesting and drainage for forestry or agriculture were considered the principal pressures Within the UK, access issues do not feature for this habitat as reasons for unfavourable condition status in the most recent JNCC review of protected sites monitoring (Williams, 2006).

5.4. Nevertheless, tramping can change surface microtopography (Bragg and Tallis, 2001). The resulting compaction can lead to gully erosion by reducing permeability of the upper peat layer or acrotelm (Bragg and Tallis, 2001;Haigh, 2006), and in accelerated runoff (Haigh, 2006).

5.5. In the UK, valley mires in lowland heathlands contain *Sphagnum* moss communities and vascular plant species such as bog orchid *Hammarbya paludosa*, which are known to be vulnerable to trampling (Lake *et al.*, 2001).

5.6. A study in Canada found that disturbance (although not specifically associated with visitor activity) was one of the top three spatio-historical factors affecting the vegetation of *Sphagnum* bogs in Canada. Moreover, spatio-historical factors account for 22% of the variation observed in the plant species assemblages while spatio-abiotic factors represent only 17% of the variation.

The results highlight the influence of anthropogenic activities on plant assemblages and suggest that even wetlands apparently resistant to disturbances, such as peatlands, can be severely affected by anthropogenic factors. Plant species assemblages of ombrotrophic peatlands of south-east Québec were, and still are, largely influenced by human activities (Lachance and Lavoie, 2004).

5.7. For the potential impact of bog snorkelling, an unusual sporting activity with higher rights elements, see the blanket bog section of the Mountain and moor chapter (see para 4.8).

Types of Site with Raised Bog with Particular Vulnerability to Access Related Issues

5.8. Recent research does not change the assessment of the original guidance (chapter 6.4) that bogs dominated by *Sphagnum* mosses are most vulnerable to trampling, albeit only with moderate or high visitor levels.

Associated Interests

5.9. No new information.

Implications of research

5.10. There seem to be few concerns regarding access on lowland bogs. Trampling can be a problem where access does occur.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

5.11. No new information.

Related Concerns

5.12. No new information.

Opportunities Associated with a Statutory Right of Access

5.13. Risley Moss Nature Reserve in Warrington (cited in para 6.6.3 of the original guidance) continues to be a ‘honeypot’ for visitor access to lowland peat bogs and mosses. Much interpretative material has been produced to assist with visitor education, and guided walks are designed to enhance visitor enjoyment while also providing a means to control access. See, for example, the leaflet at http://www.warrington.gov.uk/images/Risley%20Moss%20Nature%20Reserve_tcm15-4983.pdf.

6. FENS (Swamp and Inundation Communities)

Summary

- The situation has changed very little since 2001 when the WAAG guidance commented that there had been very little research on the impact of visitor access to fens.
- Cycling is unlikely to take place in this rather impenetrable habitat. Should horse riding take place, defaecation may result in localised nutrient enrichment, which has been shown to substantially change the characteristics of calcareous fens.
- A previous assumption that hoof prints might facilitate recolonisation of fen vegetation has now been shown to be incorrect, and thus there is no direct environmental benefit from horse riders having open access to fens.

Introduction and context

6.1. No new information to add to that published in the original guidance (chapter 7.2).

Accessibility of Sites with Fen

6.2. No new information to add to that published in the original guidance (chapter 7.2).

General Vulnerability of Sites with Fen to Direct Impacts arising from Access

6.3. The original guidance (chapter 7.3) noted that that there had been very little research on the effects of access to the fens and suggested that fens are largely self-protecting due to their impenetrability. There remains a paucity of information, and it would seem that access is not a major issue for this habitat, where most access occurs on boardwalks or similar within nature reserves (see original guidance chapter 7.2). Access is not listed as a threat within the European Commission guide to the management of alkaline fens (Šefferová Stanová et al., 2008).

6.4. While horse riding is unlikely to be a frequent activity in fens, the potential presence of horses justifies drawing attention to two studies.

6.5. First, nutrient enrichment has been found to substantially change the characteristics of calcareous fens (Paulia *et al.*, 2002). The addition of nitrogen increased aboveground community biomass by 32%. Neither total species richness nor the number of specialist species was significantly affected after two years of nutrient application. However, the number of generalist species increased after the addition of fertiliser (NPK). Changes in the abundance of the four taxonomic-functional groups and of single species suggested that species composition and richness would change over longer periods of eutrophication. To maintain the typical species composition of fens, the researchers recommend that all influences resulting in eutrophication should be minimized (Paulia *et al.*, 2002). This is of relevance because granting horse riders open access to fens would inevitably result in at least local increases in nitrogen level from dung.

6.6. Second, mammal hoof prints (from horses as well as those from any grazing mammals) have been presumed to have an important role for fen vegetation species recruitment, so there could be some theoretical benefit from permitting horse riders in fens. However, research casts doubt on this assumption (Stammel and Kiehl, 2004). Plant species revegetation of hoof prints in a calcareous fen pasture and of artificially created hoof-print like gaps in an abandoned fen was investigated over two years and compared with the surrounding vegetation. After two years, hoof prints were not recolonised reasonably, indicating that these depressions did not offer good conditions for recolonisation (Stammel and Kiehl, 2004).

6.7. Recommendations concerning grazing of alkaline fens (see Šefferová Stanová et al., 2008) advocate careful consideration of stocking densities, breeds and time of year. The authors suggest that poaching should be controlled and carefully monitored, as light poaching can help to maintain species diversity but heavy poaching can encourage the establishment of agricultural weeds such as creeping thistle *Cirsium arvense.* Based on experience from Scotland, the authors advocate that acceptable amounts of hoof prints should be no more that would occur through the occasional crossing of the fen by livestock.

6.8. There is no indication that open access to fenlands would attract mountain bikers in any considerable number, other than perhaps on tracks.

Types of Site with Fen with Particular Vulnerability to Access Related Issues

6.9. No relevant new information to add.

Associated Interests

6.10. No relevant new information to add.

Implications of research

6.11. Due to their impenetrability fens are unlikely to receive much visitor pressure and access is not likely to be a major issue on fen sites.

6.12. Cycling is unlikely to take place in this habitat. Should horse riding take place, site managers may need to be wary of the possibility of localised eutrophication (as a result of horse defaecation) and poaching. Poaching from footfall, especially from horses, can be damaging and ideally should not exceed light levels.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

6.13. The limited recent research suggests that the assessment provided in the original guidance (chapter 7.6) remains appropriate.

Related Concerns

6.14. Dog fouling is potentially an issue in this habitat, see the grassland chapter (paras 7.10 - 7.11).

Opportunities Associated with a Statutory Right of Access

6.15. No relevant new information to add.

7. LOWLAND GRASSLAND

Summary

- There has been limited research published since 2001 on the impacts of human disturbance on grasslands, and there is little substantive to add to the assessments in the original guidance.
- Research from Salisbury Plain suggests that chalk grassland is significantly less resistant to repeat trampling by vehicles and that calcareous grasslands are even slower to recover from disturbance (at least 50 years) than other types of grassland. Disturbance has also been shown to benefit exotic plant species. Accordingly, managers may wish to consider limiting access activities that create high intensity disturbance events. Finally, nutrient enrichment has consequences for soil fauna and vegetation composition., Further work might be merited on the impacts of defaecation by dogs and horses.
- Dog fouling remains a key issue for this habitat (and others). The particularly nutrient rich nature of dog faeces and the large volumes of faeces and urine on some sites result in eutrophication, loss of species diversity and an increase in vegetation height.
- There are no studies of direct relevance to lowland grassland that address either horse riding or cycling.

Introduction and context

7.1. No new information to add to the summary of habitats contained in the original guidance (chapter 8.1).

Accessibility of Sites with Lowland Semi-natural Grassland

7.2. No new information to add to the assessment in the original guidance (chapter 8.2).

General Vulnerability of Sites with Lowland Semi-natural Grassland to Direct Impacts arising from Access

7.3. There has been limited research published since 2001 on the impacts of human disturbance on grasslands. Moreover, most of it is tangential. While adding to the knowledge base, the research does not substantively change the assessments in the original guidance (chapter 8.3).

Trampling effects

7.4. A recent assessment of the impact of disturbance on chalk grasslands took place on the Salisbury Plain Training Area, the largest remaining area of this habitat in north-west Europe (Hirst et al., 2003), but concerned the impact of vehicles which is outside the scope of this study. Nevertheless, the finding that chalk grassland is significantly less resistant to repeat disturbance may be important when considering the impact of human trampling. Identifying vegetation community resistance assists understanding of the ecosystem response to long-term and cumulative stress and facilitates strategic management of habitats where disturbance events are commonplace, especially in areas of high nature conservation interest. These data demonstrate that small-scale but acute disturbance events can have significant effects on plant community composition, and can have wider reaching impacts on other aspects of site management.

7.5. A comparison of calcareous and mesotrophic grasslands on Salisbury Plain (Hirst et al., 2005) demonstrated that calcareous grasslands were less resilient following disturbance than the mesotrophic grasslands, with slower colonization of bare ground and target species re-assembly. Mesotrophic grasslands typically took 30–40 years to re-establish following disturbance, whereas calcareous grasslands took at least 50 years. Moreover, even after long time periods, there remained subtle but significant differences between the vegetation composition of the disturbed and undisturbed swards. Perennial forb species, particularly hemicryptophytes, persisted at higher frequencies in swards disturbed 50 years ago than in undisturbed swards (Hirst et al., 2005).

7.6. Recent research in Canada has confirmed that grassland species diversity changes with levels of trampling disturbance (Vujnovic et al., 2002). Lower vascular plant, moss and lichen species diversity was found in undisturbed and lightly grazed as well as in highly disturbed plots. Intermediate levels of disturbance gave the highest species diversity, because species coexistence is maintained at a nonequilibrium state and no strong competitor can dominate completely. The species richness and diversity of exotic plant species showed a significant positive relationship with the magnitude of the disturbance (Vujnovic et al., 2002).

7.7. In the UK, changes in fertiliser regimes, grazing and mowing practices and, to a lesser extent, increased disturbance and trampling, have reduced the number and diversity of forbs in improved grasslands, and thus reduced the diversity and abundance of invertebrates, in particular of foliar species (Atkinson et al., 2004). This has impacted bird distribution and populations. Species that feed on foliar invertebrates or forb seeds have been affected negatively by modern grassland agricultural practices, disturbance and trampling. Birds feeding on soil invertebrates were found to be generally tolerant of modern management practices that maintain short swards short, as accessibility to the soil has been increased (Atkinson et al., 2004).

7.8. An assessment of issues affecting grassland conservation in several then candidate accession countries to the European Union (in central and eastern Europe) noted that the recent increase in recreational horse riding had caused the conversion of valuable meadow communities into horse pastures through a change in use to support the horses used for riding (with associated changes in plant species composition), or direct vegetational damage through trampling (Young et al., 2004).

7.9. An experiment to determine the impact of cattle trampling and nutrient enrichment on grassland flora and soil invertebrates (Cole et al., 2007), while not directly relevant, may indicate the direction of influence of human access / horse riding. The study detected only minimal changes to plant diversity within the short timescale (two years); in the longer term, floral changes were predicted to occur, with impacts on soil fauna. In contrast, trampling disturbance reduced above ground biomass.

Effects of dog faeces on soils and vegetation

7.10. Since the publication of the original guidance a number of reviews have addressed the impacts of dog fouling (Taylor et al., 2005;Taylor et al., 2006). Most of the work cited within these reviews is pre 2001, and the reviews give detail on the chemical composition of faeces, behaviour of dogs and impacts. Dogs will typically defecate within 10 minutes of a walk starting, and as a consequence most deposition tends to occur within 400m of a site entrance (Taylor et al., 2005). Similarly, dogs will typically urinate at the start of a walk, but they will also urinate at regular intervals during the walk too. The total volume deposited on sites may be surprisingly large. At Burnham Beeches NNR over one year, Barnard (Barnard, 2003) estimated the total amounts of urine as 30,000 litres and 60 tonnes of faeces from dogs. Limited information on the chemical composition of dog faeces indicates that they are particularly rich in nitrogen (see work cited in Taylor et al., 2006).

7.11. Nutrient levels in soil are important factors determining plant species composition and on grassland sites the typical effect will be equivalent to applying a high level of fertilizer, resulting in a reduction in species richness and the presence of species typically associated with more improved habitats. A lush green strip is often evident alongside paths as nutrient enrichment can also lead to more vigorous growth and flowering (Taylor et al., 2006).

Effects of disturbance

7.12. Recent research on disturbance effects on grassland fauna are summarised in the relevant faunal chapters.

Types of Site with Lowland Semi-natural Grassland with Particular Vulnerability to Access Related Issues

7.13. Two findings from recent research on Salisbury Plain may have implications for site managers developing visitor access management plans and similar. First, chalk grassland is significantly less resistant to repeat trampling by vehicles at least (Hirst et al., 2003). Second, calcareous grasslands are even slower to recover from disturbance than mesotrophic grasslands (Hirst et al., 2005), taking at least 50 years compared to the latter's 30–40 years. Additionally, research in Canadian grasslands shows that disturbance benefits exotic plant species (Vujnovic et al., 2002), an issue that managers seeking to conserve native flora will need to consider.

Associated Interests

7.14. Populations of wading birds breeding on lowland wet grassland in England and Wales have declined markedly in recent decades; the loss of once widespread species such as lapwing *Vanellus vanellus*, common snipe *Gallinago gallinago* and common redshank *Tringa totanus* from many areas is of particular conservation concern (Wilson et al., 2004a). These declines are due to loss of grassland to other land uses, and to significant changes in grassland management; there is no suggestion that visitor disturbance has population-level impacts. However, given that careful management of key sites, many of them managed as nature reserves, has shown that wader declines can be halted or even reversed (Wilson et al., 2004a), site managers may wish to consider whether access management tools may be merited to avoid the risk of visitor disturbance reducing the effectiveness of habitat management.

Implications of research

7.15. Hirst *et al.* suggest that managers should limit activities that create high intensity disturbance events because the succession trajectory following such events may be less direct and with less predictable outcomes than that following lower intensity disturbances. Increased predictability of succession trajectories following medium to low disturbance events means these types of disturbance might be used deliberately to create short-term and small-scale heterogeneity in both species composition and sward structure (Hirst et al., 2003). Complementary research led the same authors to suggest that a clearer understanding of the length of time that intensively disturbed grassland takes to re-establish may encourage more effective control measures at susceptible sites (Hirst et al., 2005).

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

7.16. No new information to add.

Related Concerns

7.17. Recent research does not add any new information to the detailed assessment provided in the original guidance (chapter 8.7).

Opportunities Associated with a Statutory Right of Access

7.18. No new information to add

8. WOODLAND

Summary

- Recreational use of forests adversely affects soil characteristics (erosion, compaction, bare ground), understorey vegetation, species composition of the soil seed bank (favouring more trampling-tolerant species), and tree transpiration rates. Different species are affected to different extents.

- The effect of path-trampling on species composition and density extends for 10 m off-path. Mosses are particularly susceptible. People, dogs and horses deposit non-native or non-forest seeds, and such species are more likely to establish in frequently visited areas.

- Management considerations are many. Ground flora takes a long time to recover both density and species composition, and revegetation by seeding is only certain to work in areas where access is excluded. British woodland ground flora are susceptible to even low levels of trampling, which suggests that visitors should be concentrated in less sensitive areas rather than spread thinly over a large area. Other potential management tools include the provision of attractive paths, closure of impromptu trails, use of dead branches to accelerate soil stabilisation, the delimitation of an undisturbed core area and use of screening vegetation. Management policies should be sensitively implemented so as not to reduce visit quality for responsible visitors.

Introduction and Context

8.1. The original guidance included a chapter on wooded common land (chapter 9). In updating this chapter we broaden the scope slightly to encompass all woodland.

Accessibility of Woodland

8.2. Complex spatial analysis of visitor rates to UK woodlands, encompassing travel time, housing density, features of sites and a range of other factors has allowed predictive models to be built to determine visitor rates to Forestry Commission sites across the UK (Jones et al., 2003). The same authors have also conducted cost-benefit analyses of open access to woodland, showing that, visitor rates are more dependent upon the location of the site rather than the facilities present at the site.

8.3. Extensive research on visitors and access patterns have been conducted in the New Forest as part of the Progress Project[2], a four year project funded through the European Union. Different elements of the project have included visitor surveys, household surveys, interviews with focal groups and predictive modelling of access management scenarios. Predictions of total annual visits to the New Forest National Park are estimated to exceed 13 million. The majority of visitors are day-trippers, coming from a wide radius well outside

[2] See http://www.forestry.gov.uk/forestry/infd-6aqeua

the park boundary and virtually all arrive by car (Tourism South East Research Services and Geoff Broom Associates, 2005).

General Vulnerability of Woodland Sites to Direct Impacts arising from Access

8.4. The ecological impact of recreation in woodlands and forests is now a subject of considerable worldwide interest, although studies of the impact of disturbance on British forests remain few (Littlemore and Barker, 2001). Almost all the limited recent information comes from elsewhere in Europe but nevertheless offers insights to complement, if not substantively change, the assessment of general vulnerability contained in the original guidance (chapter 9.3).

8.5. Typical British woodland ground flora stands are generally intolerant to trampling. Rates of damage to British woodland ground flora (homogeneous stands of bluebell *Hyacinthoides non-scripta*, bracken *Pteridium aquilinum* and bramble *Rubus fruticosusi)* were most rapid at the initial stages of trampling (Littlemore and Barker, 2001). The ability of ground flora to tolerate impacts was more a function of an ability to recover from trampling, rather than to resist. Research suggests that 35 passes through bluebells by people walking will be enough for the path to still be visible a year later. In bramble *Rubus* and bracken *Pteridium* stands the number of equivalent ‘person passes’ rises to 450 and 500 respectively (Littlemore and Barker, 2001).

8.6. An experimental assessment of the impact of recreational activity in a Swiss beech (*Fagus*) forest (Amrein et al., 2005) revealed that recreational use of forests can significantly affect soil characteristics, understorey vegetation and the soil seed bank. Disturbed sites had larger areas of bare ground, increased levels of soil compaction and consequently frequently reduced soil moisture. Recreational activities did not affect any other parameters of the top soil layer (e.g. pH, organic material and mineral content) or leaf litter layer (Amrein et al., 2005).

8.7. Human trampling was found to cause a shift in the species composition of the seed bank in Swiss beech forests (Amrein et al., 2005). There was no difference in seed density between disturbed and control areas, but, interestingly, species richness in the seed banks of disturbed areas tended to be higher (and contained a higher proportion of trampling-tolerant species). The number of trampling-tolerant species was significantly higher in disturbed areas. People and dogs visiting the forest can carry non-native seeds. In frequently visited areas there is an increased probability that non-native plants can establish. Disturbed areas had a larger proportion of seeds dispersed by animals and humans (Amrein et al., 2005).

8.8. Another recent study in Belgium assessed vegetation recovery in a deciduous forest subject to recreational disturbance (Godefroid et al., 2003). Species recovery on eroded hills was related to slope aspect and soil type. Protection from recreation initiated the recovery of species in the herb layer, but it took a long time for ground flora to recover in both density and species composition (Godefroid et al., 2003). Most of the species that grow well on heavily compacted forest soil are non-forest species (Godefroid and Koedam, 2004b), which has obvious management implications. Researchers discovered that a sudden removal of trampling intensity through fencing enhances, over a relatively short term, vegetation recovery on eroded areas. Recovery time, however, varies with species, and, further, with slope, aspect and soil type (Godefroid and Koedam, 2004b)

8.9. An assessment of trampling in Mediterranean Sclerophyllus forest (Andrés-Abellán et al., 2006), although not relevant to the UK in terms of habitat type, reached some conclusions of generic interest. Frequent trampling results in a decrease of plant cover and the number of individual plants. The extent of damage depends on vegetation type, the number of cumulative tramplings and trampling intensity. The number of individual plants might be a better index of trampling impact than vegetation cover, which can (falsely) increase as a result of trampling spreading the plant horizontally. Determining the level of resistance of plant species to trampling is thought to be essential to manage recreational use by designing routes that confine visitors to trampling-tolerant vegetation (Andrés-Abellán et al., 2006).

8.10. An assessment of the impacts of trampling on mesic (*Myrtillus*-type) understorey vegetation in fragmented urban forests in Finland (Hamberg et al., 2008) may have some relevance to English conditions. Trampling decreased the cover of plant species and changed the forest understorey species composition, altering it locally on paths and providing opportunities for new species to establish in previously unbroken forest vegetation. Urban forest edges were characterised by grasses better adapted to sunny, warm and dry conditions, which replaced more sensitive forest species such as dwarf shrubs and mosses. The effect of path-trampling on species composition and density extended for 8 m off-path. Trampling may change the micro-climate on the path, which may have a negative effect on mosses off-path. Off-path, the effects of trampling were most clearly visible among mosses (Hamberg et al., 2008).

8.11. Work in Belgian forests produced similar results, with forest paths being demonstrated to have a significant effect on the surrounding plant assemblages (Godefroid and Koedam, 2004a) The presence of a path results in an increase in the number of ruderal species, disturbance indicators, nitrogen-demanding species and indicators of basic conditions. Eutrophication and pH increase, as inferred from the plant composition, are perceptible up to at least 10 m from the path. Moreover, some plant species are significantly associated with one particular type of path surfacing material, which suggests that site managers need to carefully consider any material used to surface paths.

8.12. Recent work in Japan has confirmed a previous supposition that human trampling reduces tree evapotranspiration by compacting soils, thereby altering the forest water cycle and reducing tree growth. Recovery times were substantial (Komatsu et al., 2007).

8.13. An assessment of the impact of trampling and disturbance on various focal species of fauna in France (Ficetola et al., 2007) cautions that the effect of disturbance/trampling can be very different for different species. The same factor was found to affect the distribution of some species negatively, but benefited other species in the same class (Ficetola et al., 2007). This suggests that caution is warranted when extrapolating management conclusions with regards a single species to an entire site.

8.14. In a study of attitudes of private woodland owners to public access Church *et al*. (2005) summarised the range of different impacts experienced by the woodland owners. Some of these (relevant to nature conservation) are summarised in Table 3, it can be seen that litter and erosion of paths are the most commonly experienced problems by woodland owners.

Table 3: Experience of problems of access by woodland owners in south-east England. Adapted from Church et al (Church et al., 2005) to only include issues that might relate to nature conservation. Data are from 83 questionnaires.

Problem	*Experience of problems (% of respondents)*				
	No Problem	**Minor incovenience**	**A few major problems**	**Many major problems**	**Very severe problems**
Interference with livestock	57	26	14	2	2
Gates left open	50	32	12	6	0
Erosion of paths and gateways	36	30	29	1	3
Litter	15	49	19	15	1
Fire	61	17	19	3	0

8.15. Lowland wood pasture and parkland is a BAP priority habitat and trampling (physical damage) was identified in the 2005 BAP reporting round as a current or emerging threat. The issue concerns veteran trees, where soil compaction erosion caused by trampling by people (and livestock) and car parking can be damaging (Read, 2000).

8.16. Plant pathogens can have major impacts on diverse taxa and ecological systems, and some of the most conspicuous of these are invasive non-native species, such as *Phytophthora ramorum*, which causes Sudden Oak Death. Many factors are known to influence the distribution and abundance of plant pathogens, and these include humans, through recreational access. Studies in the U.S. have found that *P. ramorum* more commonly occurred in soils on heavily used tracks compared to soil from adjacent areas off trails. Human-induced dispersal occured within already infected areas and into areas lacking local sources of inoculum (Hall Cushman and Meentemeyer, 2008). Advice from Defra indicates that Phytophthora pathogens can be spread on footwear within the UK[3].

8.17. Woodlands are already favoured destinations for horse riders and mountain bikers (Godefroid et al., 2003). The increased impact force of both activities will result in high trampling effects on woodland vegetation, presumably mainly along paths although almost two-fifths of horse riders stray off-path in the New Forest (England Marketing, 2005). The little research available on cycling and mountain biking does not enable us to judge whether woodland flora and fauna are any more or less susceptible to these forms of disturbance than in other habitats.

Types of Woodland Site with Particular Vulnerability to Access Related Issues

8.18. The original guidance highlights ancient woodland ground flora; understorey beneath a dense canopy; wet woodland; woodland on steep

[3] http://www.defra.gov.uk/planth/pestnote/2008/pramparks.pdf

hillsides and sites supporting rare species as particularly vulnerable. Recent research provides little extra detail. Vegetation types with low productivity, such as the ground flora beneath dense canopy, are highlighted as particularly sensitive to trampling by Malmivaara *et al.* (2002).

Associated Interests

8.19. No new information.

Implications of research

8.20. That damage to ground flora of a British woodland is at its most rapid when use levels are low has important implications for site management (Littlemore and Barker, 2001). Visitor access should be concentrated in less sensitive areas rather than spread thinly over a large area. Management policies should be sensitively implemented so as not to reduce visit quality for responsible visitors. If woodland trails are aesthetically pleasing, well-marked, well-drained and surfaced with non-intrusive materials, people generally stick to them. Preventing new desire lines becoming established is important, especially in winter when soils are at their most vulnerable. Screening woodland wildflowers with impenetrable vegetation such as bramble is also recommended (Littlemore, 2001;Littlemore and Barker, 2001).

8.21. Research in beech (*Fagus*) forest in Switzerland shows that intensive long-term use of forest for recreation causes an increase in non-forest plant species (Amrein et al., 2005). As disturbance alters the composition of the soil seed bank, regeneration from the seed bank of habitat degraded as a result of disturbance would alter vegetation composition. The researchers therefore consider that it is important to maintain undisturbed natural forest areas to ensure a seed flux into disturbed forest sites (Amrein et al., 2005).

8.22. Site managers are assumed to be interested in instant revegetation with forest species from the vicinity because if path structures remain visible, visitors continue to use them, which disrupts the restoration process (Godefroid et al., 2003;Roovers et al., 2005b). Two sets of research in Belgian forests found that areas denuded of vegetation and suffering from soil erosion as a result of long periods of trampling can be actively revegetated by seeding with native species provided that human trampling is excluded by dint of fencing or equivalent (Roovers et al., 2005b). The authors conclude that access restriction and path revegetation are essential components of habitat restoration after trampling and that fencing has proved to be an efficient management tool to allow vegetation regrowth. In a separate study in Belgian forests, a six-year exclusion was found to result in path centre vegetation recovering towards the plant composition of a nearby undisturbed zone (Roovers et al., 2005a).

8.23. An additional management tool suggested following work in Belgian forests was to lay dead branches horizontally to the soil, which accelerates soil stabilisation by reducing erosion, acting as a focus for biological activity, providing cover for small mammals that disseminate spores and by mitigating temperature extremes (Godefroid et al., 2003). This simple tool may be feasible without access restriction.

8.24. Based on research on bryophytes and vascular plants in Finland, site managers of urban forest fragments who seek to preserve true forest understorey vegetation are recommended to retain a core undisturbed area within a 50 m buffer zone; the size of the core area would depend on the size and shape of the forest fragment (Hamberg et al., 2008).

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

8.25. There is no new information relevant to statutory exclusion or restrictions under the CRoW Act (2000) and the recommendations in the original guidance (chapter 9.6.2; that exclusions are unlikely to be necessary anywhere but that there may be situations where restrictions are warranted) are still relevant.

Related Concerns

8.26. Access infrastructure (such as boardwalks) may result in areas of early successional habitats being lost through trampling. Path surfacing and drainage can damage important invertebrate habitat.

8.27. Dog fouling is potentially an issue in this habitat, see the grassland chapter (see paras 7.10 - 7.11).

Opportunities Associated with a Statutory Right of Access

8.28. No new information.

9. OPEN WATER

Summary

- Little research has been published since 2001 on the impacts of acess on open water.
- Research on Danish streams has revealed that disturbance (from weed cutting) has considerable impacts on stream structure and fauna, with some invertebrates and trout less abundant in disturbed streams.
- Nutrient enrichment of the water and soil erosion resulted from tourist presence at Australian and Spanish lakes.
- Two publications argue that appropriate monitoring techniques are essential to inform management decisions which, in one case, justified the access restrictions and exclusions that were necessary to reverse environmental damage.

Introduction and context

9.1. No new information to change the summary in the original guidance (chapter 10.1).

Accessibility of Sites with Freshwater Habitat

9.2. Inland areas of open water can be subject to a range of different types of recreational use. Cotswold Water Park, on the Gloucestershire-Wiltshire border has been the focus of work on disturbance (O'Connell et al., 2007). The park contains 146 different lakes and the breakdown of how these are zoned for access highlights the range and levels of use of such sites: there are more than 40 fishing lakes, 6 sailing lakes, 3 windsurfing lakes, 1 jet ski lake, 8 water skiing lakes and 1 powerboat lake.

General Vulnerability of Sites with Freshwater to Direct Impacts arising from Access

9.3. The few publications since 2001 do not substantively change the assessment provided in the original guidance (chapter 10.3), but do offer a few complementary insights.

9.4. At Peñalara Lake in the mountains of central Spain, environmental conditions started to decline in the 1970s as a direct result of increased visitor numbers initiating severe soil erosion processes and increasing nutrient load which combine to alter the composition of aquatic biological communities (Toro and Granados, 2002). In the end, the prohibition of camping and restriction of access to the lake were necessary to reverse environmental damage. Monitoring was essential to determine suitable management responses (which suggests that it might be worth considering in UK circumstances).

9.5. An assessment of the impacts of disturbance by weed-cutting in Danish lowland streams (Pedersen, 2003) may give insights into the potential impacts of visitor disturbance on this habitat in the UK. Species richness and diversity of macrophyte communities was greater in disturbed streams. In disturbed streams, current velocity was lower and mud coverage higher than undisturbed streams. Disturbed streams were morphologically less variable. In disturbed streams, macroinvertebrates adapted to slower currents and fine substrata habitats were more abundant whereas the abundance of macrophyte dwellers such as simulids was reduced by 50–90% (Pedersen, 2003). Trout *Salmo trutta* density was lower in disturbed streams due to habitat degradation and lower food resources (which resulted from weed-cutting rather than disturbance per se).

9.6. Research in Australia demonstrates that intensive recreational use of oligotrophic lakes can lead to increases in epilimnetic nutrient concentrations (through direct inputs from urine or re-suspension of sediments) and the development of undesirable algal blooms. Nutrients added to lakes by tourists are likely to be rapidly assimilated by littoral zone periphyton communities in these oligotrophic lakes (Hadwen et al., 2005).

9.7. The presence of paths (indicative of human disturbance) in the vicinity of the French gravel pits reduced both the total number of waterbirds and species richness (Santoul et al., 2004).

Types of Site with Freshwater Habitat with Particular Vulnerability to Access Related Issues

9.8. Recent research does not change the assessment of site vulnerability summarised in the original guidance (chapter 10.4).

Associated Interests

9.9. Disturbance issues pertinent to waterbirds (see paras 19.61 - 19.64) and mammals (Eurasian otter *Lutra lutra* see paras 20.9 - 20.10 and water shrew *Neomys fodiens* see para 20.11) are discussed in the Birds and Mammals chapters respectively.

Implications of research

9.10. Despite adverse ecological responses to tourist activities demonstrated by research in Australia, many lake monitoring programs do not address tourist nutrient inputs at appropriate spatial and temporal scales. As a result, impacts of tourism are not likely to be detected by traditional measurements of open water nutrient and phytoplankton chlorophyll *a* concentrations. Instead, measurement of periphyton growth and/or biomass (chlorophyll *a*) in the littoral zone might be the most spatially and temporally relevant indicator of tourist impacts in these lakes (Hadwen et al., 2005). Meanwhile, research in Spain suggested the importance of monitoring to determine suitable management responses (Toro and Granados, 2002). Such monitoring tools may assist the development of appropriate management actions.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

9.11. The paucity of recent research assessing disturbance impacts on waterbodies means that there are no grounds to substantively change the assessment in (chapter 10.6) of the original guidance. However, it is worth noting that prohibition of camping and restriction of access were necessary to reverse environmental damage at Peñalara Lake in Spain (Toro and Granados, 2002).

Related Concerns

9.12. No new material.

Opportunities Associated with a Statutory Right of Access

9.13. No new material.

10. COASTAL HABITATS

Summary

- We deviate from the structure of the original guidance and split coastal habitats into different chapters. This chapter simply addresses generic coastal issues.
- There is new material on access to coastal habitats, highlighting the popularity of coastal sites (72 million leisure visits per year to the English coast) and the wide range of activities that take place.

Introduction and Context

10.1. In the original guidance the *Coastal habitats* chapter sought to give guidance as to where coastal habitats qualified for a statutory right of access because of their incidental inclusion within registered common land. This supplement broadens the coverage of the original guidance, encompassing additional habitats.

10.2. The existing guidance outlines key material pre-2001 for sand dunes, cliff habitats, vegetated shingle and saltmarsh, which we summarise then update by highlighting post-2001 research and providing additional detail. We deviate from the structure in the original guidance and treat the various coastal habitats as separate chapters. We separate saltmarsh from mud / sand flats (although the two habitats are functionally related) and address these two different habitat types in different chapters. We also provide entirely new sections on saline lagoons, coastal grazing marsh and rocky shores. Maritime heath is included within the heathland chapter. Dune heath is a rare habitat which we cover within the dunes chapter (chapter 14). Also relevant is an update to the mammals chapter to include seals (chapter 20).

10.3. There has been extensive research into the impacts that visitors have on coastal environments. The focus has very much been on two issues, the effect of trampling on vegetation or soils and the impacts of disturbance to birds. Trampling studies have mostly addressed the characteristics of vegetation and soils that have been walked over and compared these to untrampled areas (e.g. Hylgaard and Liddle, 1981;Kutiel et al., 2000;Lemauviel and Roze, 2003). These studies have shown that increased trampling generally results in a reduction in species richness, vegetation cover, species diversity and vegetation height, and an increase in soil compaction. The impact of trampling varies between habitats. The work on disturbance to birds has shown clear population consequences for a range of species (Stillman et al., 2001;Liley and Sutherland, 2007;Stillman et al., 2007).

10.4. Since the publication of the original guidance, Flood and Coastal Erosion Risk Management policy has developed. Strategic coastal management policies are now being reviewed by second generation Shoreline Management Plans which will need to work more closely with coastal processes and recognise the contribution of the natural environment in the reduction of risk and the need for adaptation as sea levels rise relative to the land. In some cases this may mean that the coastline will change, and access management to take account of the needs of habitats and species will need to adjust to this[4].

Accessibility of Sites with Coastal Habitats

10.5. Natural England has undertaken a detailed programme of research into coastal access in order to inform their advice to government and the subsequent implementation of coastal access (Natural England, 2007). This research included analysis of spatial coastal data to determine the extent of existing access and market research (conducted by Ipsos MORI) to assess current public knowledge of, use of and demand for coastal access.

10.6. It is estimated that at least 30% of the coast lacks legal or recognised access . Moreover, a proportion of the remaining 70% does not provide continuity of access or a quality coastal experience; for example, not all stretches of promoted coastal paths actually run close to the sea. Approximately 7% of coastal Rights of Way have higher rights. The amount of legal or recognised access along the coast varies markedly between regions.

10.7. There were 72 million leisure visits to the coast (excluding seaside towns) in 2005, and the most popular activity was going for a walk (Natural England *et al.*, 2006). Half of the English public said that they did not visit the coast frequently but would like to visit more (IpsosMori, 2006).

10.8. The distribution of people within coastal sites is closely related to the distribution of car parks (Tratalos et al., 2005;Liley and Sutherland, 2007) and the presence of roads, pubs, hotels, caravan sites and public conveniences also all influence the number of visitors at beach entrances (Tratalos *et al.*, 2005). Tratalos *et al.* also found that visitor numbers on a given beach tend to decline dramatically over the first c.150 m from a car park, highlighting the importance of access points with parking in determining the spatial distribution of people along a given section of coast.

10.9. People undertake a range of activities in coastal areas. Land-based activities include walking, dog walking, climbing and sunbathing. Activities closely linked to the shoreline include fishing and coasteering. Water-based activities include windsurfing, kayaking, jet skiing, sailing and parasurfing. Access to craft can take place at designated jetties or along any section of coast. The number of people undertaking different sporting activities are summarised by Penny Anderson Associates (2006). In many areas, the range of activities and their spatial distribution may result in a complex range of different types of activities, occurring at different intensities, tide states and times, even at night (Liley *et al.*, 2008 in press). This range of activities often means that attributing impacts of access to particular pursuits can often be difficult.

10.10. There are clear differences in the levels of human recreational use of different coastal habitats. More people use sandy beaches than any other type of seashore (Schlacher et al., 2007a), and some sandy beaches in the UK hold very high concentrations of people, especially in the summer. Studland Beach in Dorset, for example, is estimated to have over one million visitors per annum (Liley et al., 2006b). Some other coastal habitats, such as cliffs and mudflats are, by their nature, difficult to access and rarely visited.

[4] See http://www.defra.gov.uk/environ/fcd/default.htm for more information

General Vulnerability of Sites with Coastal Habitats to Direct Impacts arising from Access

10.11. The vulnerability of different habitat types is now treated within subsequent habitat chapters.

Types of Site with Coastal Habitats with Particular Vulnerability to Access Related Issues

10.12. The types of site with particular vulnerabilities are now treated within subsequent habitat chapters. We highlight particular nature conservation issues regarding trampling and erosion in sand dunes, trampling on shingle, disturbance to (coastal breeding waders, terns, cliff-nesting seabirds and waterfowl on esturaries), disturbance to seals and impacts of rock climbing.

Associated Interests

10.13. Disturbance to birds is a common issue for many coastal habitats, updates within the birds chapter include sections on seabirds on cliffs (see paras 19.66 - 19.68), tern colonies (see para 19.71), coastal nesting shorebirds (see paras 19.72 - 19.80) and wintering shorebirds (see paras 19.81 - 19.92). There is evidence for disturbance effects for seals, especially harbour seals which is covered within the mammals chapter (see paras 20.15 - 20.25). There is material relevant to invertebrates within the relevant chapter (see paras 22.24 - 22.57).

Implications of research

10.14. There are a wide range of pressures on coastal habitats (Schlacher et al., 2007a) and the range of types of access and recreational use within a site can be complex. Access will usually need to be considered at a site specific level, determing the impacts and potential benefits of access in the context of other issues, such as coastal squeeze, and the species and habitats present on the site.

10.15. Specific implications for different habitats are addressed within the relevant chapters.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

10.16. No new information.

Related Concerns

10.17. The impact of dogs is an issue for many habitats, both in terms of nutrient enrichment and regarding disturbance impacts to birds.

10.18. Access can conflict with management practices such as grazing, which can be difficult to implement in areas with high levels of public access and habitat constraints such as steep cliffs or tidal habitats. More work is needed to determine how traditional grazing practices can be maintained on coastal habitats in the face of increasing public access.

10.19. Access infrastructure such as car parks are often within the coastal system and this can be an issue where coastal change requires these to be moved, with potential conflicts if the preferred location is in an area important for nature conservation.

10.20. Erosion and accretion are two important elements of coastal processes. Both are essential for the long-term evolution of the coast. Coasts have been evolving for thousands of years. A legacy of poorly planned human interventions to coastal processes means that in some areas these processes are out of balance. This will affect the ability for the coast to adjust in future, for example sediment budgets have been affected, or saltmarshes are undergoing coastal squeeze. There may be knock affects relating to access, for example failure to accept the dynamic nature of sediments and provide permanent access infrastructure may be inappropriate on some sites. Natural England advocates working with coastal processes in a strategic way to enable adaptation in the long-term.

Opportunities Associated with a Statutory Right of Access

10.21. Creation of new access routes has the potential to enhance cliff-top habitats, particularly for invertebrates (see para 22.70).

11. SALINE LAGOONS (addition to original guidance)

Summary

- Saline lagoons were not included in the original guidance.
- In general there appears to be relatively few issues relating to saline lagoons and public access and few direct studies of recreational impacts to this habitat.

Introduction and context

11.1. Saline lagoons can be defined as shallow areas of saline water—natural or artificial—wholly or partially separated from the sea by sandbanks, shingle, rocks or other hard strata or by man-made structures. They can be tideless or tidally restricted such that they retain a proportion of their water at low tide and may develop as brackish, fully saline or hyper-saline water bodies (Anon, 1995;Bamber et al., 2001).

11.2. Only 41 natural saline lagoons in the UK have been identified, covering some 660 ha. They have several origins: the enclosure of harbours or bays by marine spits or bars; the creation of pools within shingle formations; percolation pools formed from the water table; marine transgression into low lying areas; and streams or estuary mouths being dammed by sand or shingle bars (Barnes, 1989). Other lagoons have been created by humans, by excavation of land near the sea including the extraction of gravel from shingle deposits to form percolation pools and the deliberate construction of saline lagoons on nature reserves by excavation and sluicing.

11.3. Saline lagoons vary in their character and fall into five broad categories (after Smith and Laffoley, 1992;Downie, 1996):

- Lagoonal inlets permanently connected to the sea through a restricted channel, with varying salinities from seawater in the channel to freshwater from inland streams and springs;
- Isolated from the sea by a permeable or impermeable barrier so that the salt water influence is from groundwater seepage or occasional very high tides or storms;
- Percolation pools, isolated from the sea by a permeable shingle barrier which allows varying amounts of salt water through the shingle during high tide periods;
- Silled lagoons, partially separated from the sea by a sill, so that water is retained at all states of the tide but with some tidal exchange at higher tides;
- Sluiced ponds where water is retained by sluices or other controlled structures.

11.4. Including artificial lagoons, there are some 12 saline lagoons in Wales and 177 in England covering 1,200 ha out of a total UK resource of 4,900-5,200 ha. Coastal lagoons are a scarce habitat in the EU with a restricted distribution on the Atlantic coast. Lagoons formed by a sedimentary barrier (beach, spit or chain of islands, often of shingle) and silled lagoons (in Scotland) are particularly notable as features in the UK (Barnes, 1989;Covey, 1999). Under the Habitats Directive, saline lagoons have been identified as an Annex I priority habitat. In England and Wales seven lagoon sites have been selected as SACs, and a further five are included in SACs where the Annex I habitat is a qualifying feature but not the primary reason for site selection.

11.5. Just over 50% of the lagoonal sites in England are in designated SSSIs, 10% of sites are within NNRs and a further 10% in LNRs (Bamber *et al.*, 2001).

11.6. Four plant species, 20 species of invertebrate and one bird (the avocet *Recurvirostra avosetta*) are wholly or mostly reliant on saline lagoon habitat in the UK. Of these 11 are red data species and six UK Biodiversity Action Plan Priority Species (Cadbury *et al.*, 2001). Saline lagoons can support breeding birds and their chicks, including avocet, ringed plover *Charadrius hiaticula*, lapwing *Vanellus vanellus* and redshank *Tringa totanus*, and where there are islands, breeding colonies of gulls *Larus* and terns *Sterna*. Some deeper lagoons attract wintering and roosting wildfowl and waders and roosting gulls and terns.

11.7. Plants in saline lagoons are mostly stoneworts (*Chara, Lamprothamnium* and *Tolypella* spp.) and tasselweeds (*Ruppia* spp.). Such species generally prefer low to moderate salinities with clear water and low nutrient levels. A wide variety of invertebrates are also found in saline lagoons including sea firs and sea anemones (*Cnidaria*), sea mats (*Bryozoa*), a number of worm species (*Annelida*), snails, slugs and bivalves (*Mollusca*), ostracod, isopods, amphipods and shrimps (*Crustacea*) and a small number of beetle (*Coleoptera*) and fly (*Diptera*) species. Little is known of the biology of some species, but a range of substrates and salinities, submerged vegetation and specific features such as marine seepages can all be important components. The rare stonewort *Lamprothamnium papulosum* is considered to be particularly sensitive to high phosphorus levels (Cadbury *et al.*, 2001).

11.8. Evolution of lagoons may occur, and their size and distribution may change. New lagoons may form if there is adequate sediment, others may experience a form of coastal squeeze (Barnes, 1991).

Accessibility of sites

11.9. Many saline lagoons (such as the famous scrape at Minsmere) are located within nature reserves where access is limited and viewing facilities are provided. At other sites, such as elsewhere on the Suffolk coast and sites on the Norfolk coast, lagoons are easily accessible from the sea wall.

General vulnerability of sites

11.10. The main threats to coastal lagoons are from: coastal defence works; development pressures and landfill; sea level rise; changes in the sea water/freshwater balance; water pollution and particularly eutrophication and natural succession (Johnston and Gilliland, 2000;Cadbury et al., 2001;Covey and Laffoley, 2002a;Symes and Robertson, 2004). The following human activities have been identified as potentially damaging to saline lagoons and their wildlife (Bamber et al., 1993;Saunders et al., 2000;JNCC, 2007):

- Fishing;
- Bait digging, bait collection and shellfish collection for food with associated trampling and disturbance;
- Modification of inlets/outlets associated with leisure developments;
- Drainage, dumping and litter pollution;
- Dumping and spillages of toxins into inlets or directly, including algicide and pesticide applications to reduce perceived toxic blooms or mosquito infestations;
- Discharges of sewage from coastal developments including caravan sites or non-point pollution with nutrient from agricultural or other land into inlets or directly;
- Disturbance from people and pets to breeding/wintering/passage birds;
- Introduction of alien species;
- Boating, dinghy sailing, canoeing and personal water crafts from launching, anchoring and moorings; and
- Sub-aqua and snorkelling.

11.11. Some activities can have indirect effects. One example is soil erosion from people, horses and vehicles, which causes run-off with subsequent turbidity in adjoining lagoon water columns. Another example is the use of adjoining beaches resulting in litter and eutrophication from faeces (Saunders *et al.*, 2000).

Implications of research

11.12. In general there appears to be relatively few issues relating to saline lagoons and public access.

Associated Interests

11.13. Many saline lagoons are on the landward side of a sea wall and where people walk along the sea wall they are often clearly visible (against the skyline) to any birds on the lagoon. Disturbance to waterfowl and roosting waders are an issue in some locations (sites such as Snettisham, on the Wash, support very large bird roosts) (see the birds chapter, para 19.88). Breeding birds may include terns (see the birds chapter, para 19.71) and waders (see chapter 19, paras 19.72 - 19.80).

Related Concerns

11.14. Key nature conservation objectives for saline lagoons are likely to comprise the maintenance of salinities in the range of 15–40‰ with both temporal and spatial variability in salinities and sea-water inputs exceeding freshwater inputs (Bamber *et al.*, 2001). Lagoons with some direct connection with the sea have the highest probability of colonisation by lagoonal species, which are thought to disperse via planktonic larvae, seeds or oospores through the open sea (Cadbury *et al.*, 2001). It is would therefore seem important that recreational use and associated infrastructure does not restrict or change these connective features.

11.15. Similarly, a number of lagoons have freshwater inlets with moderate salinities, and these freshwater sources should be neither diverted nor changed, for example by abstraction or impoundment, for tourist activities. Water quality should also be conserved, and any activities that might cause eutrophication, including sewage disposal from developments, caravans, boats, or on adjoining areas, dogs, should be prevented. Contingency plans should be in place to address spillages of potentially damaging materials. Water sports can be a cause of disturbance to benthic communities, from launching, anchoring and wash, with the effects likely to be greatest on smaller lagoons.

12. COASTAL GRAZING MARSH (ADDITION TO ORIGINAL GUIDANCE)

Summary

- Coastal grazing marsh was not included in the original guidance.
- Access is typically along seawalls, where borrow dykes will often prevent access directly onto the grazing marsh.
- Key issues with this habitat relate to disturbance to birds (people on sea walls tend to be clearly visible), an issue both during the breeding season and the winter.
- There may also be issues relating to the spread of non-native plant species.

Introduction and context

12.1. In a guide to wet grassland in the UK (Benstead *et al.*, 1997), coastal grazing marsh was defined as part of a wider category of wet grasslands with intensive water level management on drained soils and is still categorised with floodplain grasslands in the UK biodiversity Action Plan. In a slightly later European wet grassland handbook (Benstead *et al.*, 1999), coastal grazing marshes were defined as polders and coastal grazing marshes behind a sea wall, i.e. wet grassland areas reclaimed from saltmarshes or the sea. This definition would cover the normal situation in England wher most grazing marshes are separated from inter-tidal land by a sea wall.

12.2. Coastal grazing marsh is recognised as a distinct coastal habitat type in the UK in the SSSI selection guidelines (NCC, 1989) where it is defined as "enclosed, unimproved or semi-improved salt marsh". The habitat is not listed in Annex I of the Habitats Directive. However it is important for its bird and other brackish and freshwater wetland species and may be included in SPAs or Ramsar sites for these interest features.

12.3. We differentiate coastal grazing marshes from inland wet grasslands as they exhibit a number of vegetational, structural and topographical differences which can affect their use by both wildlife and people.

12.4. The extent of coastal grazing marsh in England was estimated at c.217,000 ha in 1993 (Dargie, 1993). Earlier estimates of loss rates had been between 1–2% per annum for areas in north Kent, Essex, Romney Marsh and the Thames Estuary, mostly through agricultural improvement and conversion to arable land (Williams et al., 1983;Sheail and Mountford, 1984;Williams and Hall, 1987;Thornton and Kite, 1990). It has been estimated that some 200,000 ha of lowland wet grassland was lost between 1940 and 1980. However, there has been little overall loss of grassland to arable land since the early 1980s (Wilson *et al.*, 2005).

12.5. In England the current extent of coastal grazing marsh is not known, but it is part of a wider category of coastal and floodplain grassland of which some 36,859 ha is within SSSIs. The situation in Wales is similar with a total of

53,600 ha of grazing marsh habitat of which 7,460 ha is notified as SSSI (UK Biodiversity Partnership, 2007).

12.6. Most coastal grazing marsh has been reclaimed from high level saltmarsh and isolated from the sea by the construction of a silt or clay sea wall. The wall is normally higher than the adjoining grass marsh on the landward side and the latter is also often lower than the saltmarsh on the seaward side of the wall, which has continued to accrete following reclamation of the marsh. Shrinkage of the soils following drainage and further reduction of ground levels due to erosion and oxygenation of soils can result in the oldest marsh (which may at some time have been under arable cultivation) having the lowest ground levels. The material for the wall is usually (but not always) excavated from the inland side, leaving a wide and often shallow ditch called a borrow dyke, which fills with water and/or is colonised by reeds and other vegetation.

12.7. The sea wall also cuts off any pre-existing drainage system of creeks and runnels that formerly drained the saltmarsh. This system often persists, providing a ready-made drainage system for the new grassland as well as a range of wet and damp features and topographical variation to the marsh surface. Where the marsh is converted to arable use, this system is usually filled in and replaced by linear ditches.

12.8. The continued saline influence from sea spray and seepage continues to affect the marsh, and borrow dykes often have a brackish influence. The grasslands contain plant communities with salt-tolerant species and often have well-defined communities recognised in the National Vegetation Classification (Rodwell, 1992). In addition, the grasslands also often have a well-defined transition from brackish communities behind the sea wall to terrestrial and freshwater communities inland.

12.9. Rare plant species associated with coastal grazing marshes in England include bulbous foxtail grass *Alopecurus bulbosus*, marsh mallow *Althaea officinalis*, slender hare's-ear *Bupleurum tenuissimum*, sea clover *Trifolium squamosum*, dittander *Lepidium latifolium*, galingale *Cyperus longus* and divided sedge *Carex divisa* (Jefferson and Grice, 1998). To these can be added the scarce saltmarsh goosefoot *Chenopodium chenopodioides* and annual beard grass *Polypogon monspeliensis* (Stewart *et al.*, 1994).

12.10. There are a number of molluscs, crustaceans, water-bugs and water beetles that prefer brackish conditions and a further suite of species that are tolerant of brackish and freshwater (Drake, 1988). Some of these are rare, endangered or vulnerable (Shirt, 1987;JNCC, 1991).

Accessibility of sites

12.11. For most coastal grazing marshes access is limited due to the nature of the terrain. Access is usually along the top of the sea wall. Where present, borrow dykes often provide a barrier to access between the sea wall and the coastal marsh.

General vulnerability of sites

12.12. Between 1982 and 2002 there were significant declines in numbers of breeding lapwing (38%) and redshank (29%) on lowland wet grassland in England and Wales, but it is not known if the scale of these declines differed between inland and coastal wet grasslands. It is probable that these declines have been driven by a switch from hay to silage accompanied by improved drainage, increased stocking densities and an earlier start to the grazing season, and increases in re-seeding and fertiliser use leading to reduced species-richness in swards and a concomitant reduction in invertebrate food (Wilson *et al.*, 2005).

12.13. The requirements of breeding wader populations on coastal grazing marsh relate to variation in sward structure (tussocks) rather than a particular sward height. Year-round grazing by sheep or abandonment of grazing results in unsuitable swards, and early grazing can deter waders and reduce their productivity. Wet rills are important feeding places for redshanks, lapwings and their chicks (Soikkeli and Salo, 1979;Milsom et al., 2000;Hart et al., 2002). Pools in May and June are important to lapwing and redshank adults and chicks, and adult redshank also fly out to estuarine habitats to feed (Johannesen and Ims, 1996;Ausden et al., 2001). Breeding waders on coastal marshes avoid hedgerows, roads and pylons (Reijnen et al., 1996;Milsom et al., 2000).

12.14. The main threats to coastal marshes derive from sea level rise associated with climate warming, changes to farming practices including conversion to arable if the economics of stock farming and arable farming change, and, at a local scale, the construction or extension of ports and other developments.Reviews of coastal protection measures may also result in effective abandonment where sea wall maintenance is considered uneconomic, or as a result of decisions to re-create coastal ecosystems through programmes of managed retreat. In either case, coastal grazing marshes may be converted back to a tidal regime.

12.15. A further consequence of human activity around grazing marshes has been the introduction of highly invasive alien plant species into grazing marsh dykes, notably New Zealand pigmy weed *Crassula helmsii*, floating pennywort *Hydrocotyle ranunculoides* and parrotfeather *Myriophyllum aquaticum*. These species are highly invasive, difficult to control and, if unchecked, will cover the surface of the water, reducing the light and shading out other plant species and eliminating or severely restricting populations of fish and invertebrates (Newman, 2000;Huckle, 2002;Newman, 2003).

Implications of research

12.16. The typical nature of coastal grazing marsh, with ditches and borrow dykes essentially limiting where people can get to, and access typically in a linear route along a raised sea wall, means that access impacts are likely to be limited to a small part of sites.

Associated Interests

12.17. There is little evidence of impacts of access to this habitat, apart from the obvious issue of disturbance to birds (see chapter 19).

Related Concerns

12.18. Sea-level rise and managed retreat / realignment may result in difficulties in access along sea walls, and there may be a need to plan for new routes with a consequent need to assess the consequences of altered access patterns and disturbance to wildlife.

13. ROCKY SHORES (ADDITION TO ORIGINAL GUIDANCE)

Summary

- Rocky shores appear generally robust, and suffer little from human activities.
- Trampling can reduce directly damage seaweeds and reduce their cover. Fauna such as worms, sponges and bivalves associated with rocky shores can also be damaged by trampling.
- At heavily visited sites there could be issues relating to disturbance from excessive rockpooling, or turning of boulders to search for marine life.

Introduction and context

13.1. Rocky shores can be defined as areas of horizontal or sloping hard rock between mean high and low water on the coast. Where the habitat can be reached by the public, it would generally be accessible by walking or scrambling without the help of climbing aids; it excludes vertical cliffs. Rocky shores comprise about 35% of the coast of the UK (JNCC, 1996).

13.2. Rocky shores as defined above are not included among the Habitats Directive Annex I habitat types. Although areas of rocky shore may be included in a number of SACs designated as reefs, estuaries, large shallow inlets and bays and particularly vegetated sea cliffs of the Atlantic, they are not recognised as a distinct habitat type. There are also many SPAs that contain sea cliffs, islands and associated rocky shore components that have not been quantified. Similarly, many coastal SSSIs contain rocky shore features although these were not part of the original SSSI selection criteria under which many SSSIs were designated, but were included in a later supplement (NCC, 1989;JNCC, 1996). Some SSSIs have been re-notified since these newer guidelines have been available (Sue Rees, *pers comm.*).

13.3. Rocky shores are dominated by species which are adapted to alternate immersion in seawater and exposure to air, as tides rise and fall. Not only do species need to adapt to immersion and desiccation, but they also need to be able to withstand the pounding of waves (including from fierce Atlantic storms), either by the use of firm anchorages or by behavioural mechanisms. In doing so, species make full use of the rugged nature of the shoreline with inlets, caves, cracks and crevices, hollows, rock pools and boulders. The extent of the rocky shore intertidal habitat will depend on the configuration of the rock and the extent of the tidal range at any particular site. The range of animals and plants found in any particular area will be a function of the type of rock (whether smooth or rough, hard or soft, acid or alkaline), the slope of the shore, the tidal range and the degree of exposure to the wave action of the sea.

13.4. The shore community depends on the level of exposure. On the most exposed shores, the community is dominated by limpets, barnacles and mussels. On moderately exposed shores, barnacles and brown seaweeds (fucoid algae) predominate, while fucoid and red algae are dominant on sheltered sites. Species of algae provide shelter, shade and dampness for a wide range of fauna, especially Gastropods and Crustacea. On less stable hard substrates, emphemeral algae grow during summer and support mobile animal communities, mostly small prosobranch molluscs and crustaceans. A number of specialised algae and lichens are found in the splash zone.

Accessibility of sites

13.5. Rocky shores are used for a range of human activities including bait collection, shellfish and crab harvesting, rock pooling, natural history studies and specimen collection (including turning over rocks), scrambling and walking, sunbathing, swimming (in the larger pools), fishing, sub-aqua and water sports in the adjoining sea, and rock climbing on adjoining cliffs (Duran and Castilla, 1989;Addessi, 1994;Murray et al., 1999;Pinn and Rodgers, 2005;Smith et al., 2008).

General vulnerability of sites

13.6. The main impacts of human activity are trampling and harvesting, a combination that can also cause disturbance, for example to birds.

13.7. There have been a large number of studies of trampling on rocky shores in the UK, Mediterranean, New Zealand, Chile and, particularly, California. These have generally shown that trampling causes a reduction in cover of a range of algae species. The extent of damage increases with the intensity of trampling. Increased intensity of trampling leads to increases in the amount of emphemeral algal species and extends recovery times from months to years (Fletcher and Frid, 1996;Keough and Quinn, 1998;Schiel and Taylor, 1999;Beauchamp and Gowing, 2003;Milazzo et al., 2004;Irvine, 2005). The extent of damage and removal does not seem to be affected by the hydration state of the algal mat. Where the plant cover is not removed, effects of trampling can cause loss of vesicles or air bladders and reproductive structures (Keough and Quinn, 1991;Denis, 2003).

13.8. Trampling can also cause a reduction in species richness (Pinn and Rodgers, 2005;Van de Werfhorst and Pearse, 2007) with a decrease in larger branching algae and an increase in smaller emphemeral and crustose species (Pinn and Rodgers, 2005), at least during the summer (Fletcher and Frid, 1996). There is also a reduction in coralline algae (Keough and Quinn, 1998), which is greatest where there was desiccation following the removal of the brown alga *Fucus* canopy (Schiel and Taylor, 1999). Jenkins (2002) found no reduction in turf-like algae, but experimental trampling levels within the observed range of trampling by visitors caused losses of turf-like algae in another study (Brown and Taylor, 1999).

13.9. Reduction in algal cover and increase in bare rock can continue after trampling has stopped (Jenkins *et al.*, 2002), effects can be variable depending on the degree of summer desiccation (Keough and Quinn, 1998), and communities damaged in autumn can take longer to recover than those damaged in spring as recovery is greatest during the spring and summer (Schiel and Taylor, 1999).

13.10. Various studies have found trampling damage to rocky shore fauna, with both macrofauna (some bivales, anemones, barnacles, limpets, whelks, sea stars, amphipods, polychaetes, isopods, oligochaetes and gammarids) and meiofauna (nemotodes, ostracods, acarids, tanaids, some bivalves, polychaete, oligocheate and annelid worms, sponges and caprellid amphipods) reduced in number (see invertebrate chapter, paras 22.24 - 22.27). Trampling and casual damage to algal mats removes cover and has a knock-on effect on the associated fauna. The deliberate removal of limpets by kicking them off the rocks has also been recorded (Pinn and Rodgers, 2005).

13.11. There seem to have been few studies on the effects of harvesting on rocky shores. The main species are shellfish, crustacea and sea urchins for bait or food, and the general effect of over-harvesting is to reduce populations and remove old adults (see invertebrate chapter, paras 22.24 - 22.27).

13.12. Harvesting (as well as other activities including educational trips) can involve turning over rocks. This can be particularly damaging as organisms can be crushed when the rock is turned over or put back, or they can be exposed to predation wave action or desiccation (Anon, 2005). Constant turning of the same rocks can result in so called ‘monk’s head rocks’ with only a fringe of organisms around the edge and no flora or fauna on the top and underside (Addessi, 1994).

13.13. There is a long tradition in the UK of rock pooling by children, which serves as a way of educating them about shore wildlife. There is no evidence that the rocky shore flora and fauna around our coasts is being significantly damaged by this recreational activity. There are few studies, however, and evidence from around the world shows that damage can be substantial and long lasting where human use is intense. It would thus be surprising if the UK did not also suffer similar effects, albeit localised around holiday areas.

13.14. Research suggests that visitors to rocky shores who had a greater knowledge of intertidal ecology were more likely to have a greater impact than visitors with less knowledge (Alessa *et al.*, 2003).

Implications of research

13.15. Rocky shores appear generally robust, and suffer little from human activities such as recreation or disturbance.

13.16. Trampling can reduce directly damage seaweeds and reduce their cover. Fauna associated with rocky shores can also be damaged by trampling.

13.17. At heavily visited sites there could be issues relating to disturbance from excessive rockpooling, or turning of boulders to search for marine life.

Associated Interests

13.18. Invertebrates are the key associated interest with this habitat.

14. DUNES

Summary

- In this chapter we update the sand dune chapter in the original guidance by exploring issues relating to erosion, dune stabilisation and access. We also consider the impacts of horse riding and cycling on sand dunes.
- Access is but one of a range of factors (such as grazing levels and wind) that can influence bare ground creation and erosion with a dune system. For most dune habitats (fore dunes are the exception), the level of impact will be proportional to the amount of access, with yellow dunes particularly sensitive. Small amounts of access have a disproportionate impact in fore dune habitats.
- Coastal sand dunes have experienced impacts of artificial over-stabilisation and there is potential for trampling to be used as a means of re-invigorating surface movement of sand to restore some of the necessary dynamism of this habitat for some of the more diverse vegetation types.

Introduction and context

14.1. Sand dunes were included within the coastal habitats chapter of the original guidance. This chapter therefore relates back to the original and simply provides an update where new material is available.

14.2. Within this chapter we address coastal dune systems and not inland dune systems, although we recognise that there may be cross-over between the two habitats.

14.3. Sand dunes are dynamic systems, changing in response to various climatic factors. The shape and size of dunes depends on the supply of sand and the strength and direction of the prevailing wind. In England, much of the 11,897 ha of sand dunes are concentrated into a small number of key locations around Northumberland, Lincolnshire, Norfolk, Kent, Dorset, Devon, Cornwall, Lancashire and Cumbria. There are around 50 sand dune SSSIs, covering over 10,000 ha (Covey and Laffoley, 2002b). Sand dune sites can also be of SSSI interest for active geomorphology.

14.4. There is a growing realisation of the difficulties in managing dynamic coastal habitats for conservation in the context of sea level rise, increased storminess and coastal squeeze. In 1994 only 21 of the 121 English dune systems visited by Radley (1994) were recorded as undergoing net progradation (lateral outbuilding towards the sea). Coastal erosion is the dominant process affecting most contemporary dune systems (Lee, 2001;Ritchie, 2001;Crooks, 2004) and net loss of habitat is "perhaps the greatest challenge facing dune conservation" (Hopkins and Radley, 2001). Loss of sand dune habitats within England from 2002–2022 is expected to be some 237 ha, which constitutes 2% of the total area (Covey and Laffoley, 2002b) and net loss of dune habitat is anticipated in Wales (Saye and Pye, 2007). The solution to these challenges is not dune stabilisation, as it is the dynamic nature of the dune system that creates many of the specialised niches and important micro-habitats within the system.

Accessibility of sites

14.5. For many visitors the beach is the main destination, and access to the dunes is restricted to crossing the dune system to reach the sea. In managed coasts there is often infrastructure guiding visitors from the back of the dune system to the beach. Increasingly, however, as in the Netherlands, the dunes themselves can be a focus for recreational activities involving vehicles, pedestrians, cyclists and horse-riders (Houston, 2008).

General vulnerability of sites

14.6. The original guidance highlights the impacts of trampling, citing a range of studies. The guidance notes that experimental work has demonstrated that light levels of trampling can increase plant diversity, but moderate to high trampling can lead to increased bare ground, soil compaction, loss of plant species diversity and changes in vegetation height. Differences exist between dune habitats. Some examples of trampling of dune invertebrates are given.

14.7. There is a range of new material published post 2001. This includes Houston *et al.* (2001), the proceedings of a conference held in 1998 that provides a range of case studies on conservation practice relating to sand dunes. There has also been a suite of studies addressing impacts from off-road vehicles, which while out of the scope of this report do highlight trampling issues for this habitat (Atkinson and Clark, 2003;Moss and McPhee, 2006;Groom et al., 2007;Schlacher and Thompson, 2007;Barca-Bravo et al., 2008;Schlacher et al., 2008a;Schlacher and Thompson, 2008;Schlacher et al., 2008b;Van Dam and Van Dam, 2008), mainly focusing on impacts to sandy beaches rather than the dunes themselves. There have also been a number of studies addressing impacts of access on sand dunes and their invertebrates (Bonte et al., 2003;Arndt et al., 2005;Bonte, 2005;Bonte et al., 2006;Barca-Bravo et al., 2008;Ugolini et al., 2008;Bonte and Maes, in press).

14.8. Access is one of a variety of factors (such as wind and grazing levels) that influences bare ground creation and erosion within a dune system (Ritchie, 2001). Access from windsurfers crossing dunes to access the shore (Angus, 2001), off-road vehicles (e.g. Schlacher and Thompson, 2008) and pedestrians (Reimers, 2001) may all result in increased bare ground and surface sand movement.

14.9. In terms of nature conservation interest, a key objective is likely to be maintainence of different types of habitat within a dynamic dune system (e.g. Hopkins and Radley, 2001), thereby ensuring that a mosaic of habitats, from early successional habitats to stabilised, fully vegetated grey dunes are all present. Actions that ensure permanent stability, particularly through fixed vegetation, can be counterproductive to the natural needs of dune systems, which require a mobile, changing and responsive environment (Williams and Davies, 2001).

14.10. It is therefore important to consider access impacts on dune systems within the context of the site, the levels of pressure and the nature conservation interest. Light trampling or disturbance may even be beneficial, but it is generally accepted that recreational pressure results in a decrease in species diversity within dunes (Bonte and Hoffman, 2005), and that a threshold can be reached where irreversible damage can occur (Curr et al., 2000;Ritchie, 2001;Covey and Laffoley, 2002b). However, it is often difficult to identify at what point this may threshold may occur.

14.11. There are examples of sites where human erosion within a dune system is seen as positive (Reimers, 2001) and the dominance of perennial plants and stabilisation of dunes has been attributed to a lack of access (see Kutiel, 2001). For many sites, a key issue with access is therefore how to achieve appropriate levels of visitor pressure within a mosaic of habitats that changes in distribution over time.

14.12. Studies of dune networks around the Mediterranean, using aerial photography (Curr *et al.*, 2000), used the length of the path network as a surrogate for visitor pressure. Dunes with low visitor pressure exhibit short, narrow paths and relatively small additional areas of bare sand in relation to the undisturbed cover. High visitor pressure on the dunes results in many interlinked paths, path widening and extension, and enlargement of the path nodes.

14.13. A survey of Scottish sand dune systems, led to a proposal that an acceptable proportion of bare sand within a site might be 2.5% (Ritchie, 2001). Much higher percentages of bare ground may be acceptable in some circumstances, especially where specialised dune invertebrates occur (L. Howe, *pers. comm.).*

14.14. Coombes (2007) explores the relationship between the amount of passes (footfalls) and reduction in vegetation cover in different habitats. For most habitats (yellow dunes, grey dunes and saltmarsh) the relationship appears to be linear, suggesting that the impact is proportional to the amount of access. The slope is steepest for yellow dunes and shallowest for saltmarshes, suggesting that yellow dunes are the more sensitive. The relationship for foredunes appears—uniquely among the habitats assessed—to be curvi-linear, with a small amount of trampling resulting in a disproportionately high impact.

14.15. An experimental study of dune trampling effects on vegetation compared the resistance and resilience compare of three typical plant communities belonging to mobile dunes, semi-fixed dunes, and fixed dunes. Only the vegetation cover of the semi-fixed dune benefited from long-term trampling and had a very high resilience. This response was explained largely by soil compaction increasing soil stability and moisture content (Lemauviel and Roze, 2003).

14.16. Human access to dunes has been associated with the spread of alien plants (Houston, 2008). Houston gives an example of the Sefton Coast, where a band of boundary vegetation with high incidence of garden-sourced exotic species exists where housing development is adjacent to the dunes.

Implications of research

14.17. There are clear impacts of trampling in dune systems. Trampling can lead to increases in bare ground, compaction, surface movement of sediment, loss of vegetation species diversity and cover. Mobile dunes and fixed dunes may be the most vulnerable.

14.18. For most dune habitats the impact will be in proportion to the amounts of access. The exception is foredunes, where small amounts of trampling have a disproportionate effect.

14.19. Trying to stop erosion to enable access to continue on a fixed route is likely to result in increasingly expensive and ineffective solutions.

14.20. There is an increasing need to address over-stabilisation of sand dune surfaces and subsequent reduction in diversity of habitats. This is a complex area as it is potentially affected by a range of factors interacting, including artificial stabilisation, nutrient deposition, lack of grazing and soil development. There is potential for trampling to be used as a means of re-invigorating surface movement of sand to restore some of the necessary dynamism of this habitat for some of the more diverse vegetation types.

Associated Interests

14.21. Impacts to invertebrates are addressed in the invertebrate chapter (see chapter 22, paras 22.28 - 22.40). Some dune systems are important for reptiles (such as sand lizards) and amphibians (such as natterjack toads), further details on these species is provided in the herptile chapter (chapter 21).

Related Concerns

14.22. Nutrient enrichment from dog fouling is relevant to dune systems, additional information is provided in the grassland chapter (see paras 7.10 - 7.11).

15. MARITIME CLIFFS

Summary

- By their very nature cliffs are largely inaccessible to access.
- Impacts relating to this habitat include disturbance to colonial nesting seabirds, disturbance to breeding raptors, vegetation damage and loss on cliff faces where rock climbing takes place, and difficulties relating to grazing management on cliff slopes with public access.

Introduction and context

15.1. Around 1,200 km (20%) of England's coastline consists of cliff (Covey and Laffoley, 2002b) which range from mud and soft rocks to hard cliffs of granite, limestone or sandstone.

15.2. Hard rock forms vertical or near-vertical cliffs, which are almost entirely inaccessible to people and often support large colonies of breeding seabirds. Vegetation communities exhibit distinct zonation due to the influence of salt spray and there are a number of specialist lichens. Soft cliffs are formed of relatively loose material such as shale or boulder clay, which may be inter-bedded with harder rock layers. They slump as they erode and are easily colonised by vegetation, forming slopes rather than vertical cliffs, often with areas of seepage and standing water. Soils that have been recently exposed following landslips develop pioneer plant communities. Longer-lived plant communities dominate older surfaces and eventually lead to scrub and woodland on the most stable slopes. The mosaic of habitat types on soft cliffs provides a range of conditions for plants and animals, and there are a wide range of specialist and rare species associated with these habitats (e.g. Covey and Laffoley, 2002b;Gilbert and doi:, 2003;Howe, 2003;Howe et al., 2008b).

15.3. This chapter also includes sea cliff slopes and combes, coastal valleys that are often associated with cliffs that also often contain exceptional wildlife interest (Oates, 1999).

15.4. The original guidance includes a very short chapter on maritime cliffs, referring only to general effects and no specific case studies. Since the publication of the original guidance there has been a surge of interest in soft cliff habitats (Rees, 2002;Howe, 2003;Whitehouse, 2005;Whitehouse, 2007;Howe et al., 2008b). There have been two notable new studies on the impacts of disturbance to cliff-nesting birds (Beale and Monaghan, 2004b;Brambilla et al., 2004).

Accessibility of sites

15.5. Cliff habitats, by their very nature, receive little access pressure compared to the other coastal habitats, and these pressures tend to be either on the cliff-top habitats or at the base of the cliffs.

General vulnerability of sites

15.6. The two principal issues regarding cliffs and access are rock-climbing and disturbance to birds. There have been a range of studies (all from outside the UK and only one directly relating to maritime cliffs) addressing the impacts of rock climbing (McMillan et al., 2003;Brambilla et al., 2004;Müller et al., 2004;Rusterholz et al., 2004;Kuntz and Larson, 2006a).. There are also a number of other factors relating to site management, such as conflicts with grazing and access or access infrastructure.

15.7. Disturbance to birds is addressed in the chapter on Birds (chapter 19), recent research has shown breeding success of cliff nesting seabirds to be affected by visitors viewing a colony

15.8. By rock-climbing we mean a variety of activities such as abseiling, coasteering and the actual scaling of cliff faces (see Penny Anderson Associates, 2006 for overview of the different types). Most rock-climbing is undertaken by climbers in small groups. Climbers prefer clean, dry rock faces free of vegetation (and lichen), soil and water seepage (Penny Anderson Associates, 2006).

15.9. Most studies of rock climbing are on inland, rather than maritime cliffs and are therefore discussed elsewhere within this report (see the mountain and moor chapter). Of particular relevance regarding coastal cliffs are the studies that show impacts of disturbance for nesting peregrines (Camp and Knight, 1998) and impacts on lichens (Farris, 1998).

15.10. There have been access issues relating to grazing of cliff slopes and public access. Due to the difficulties of fencing cliff slopes and the constraints of the terrain, public and livestock can be compressed into a narrow area. Oates (1999) was aware of over 40 instances of animals in use in conservation grazing schemes being lost over unfenced cliffs and deemed dog-worrying to be the cause in the majority of instances. Farmers and graziers can be reluctant to graze such sites and as grazing is often important for the management this can have major impacts on the conservation interest of the site.

Implications of research

15.11. Rock climbing should be an issue of concern for site managers where nesting raptors or seabirds occur, or where there is plant interest on the cliff face.

15.12. Consideration of how visitors access or view seabird colonies is warranted.

15.13. Careful consideration is necessary relating to the management of livestock where grazing takes place on cliff slopes with public access.

Associated Interests

15.14. Fossil collection may be an issue at some sites, see the earth heritage chapter. The birds chapter addresses disturbance issues to sea birds and birds of prey. Rock climbing is addressed within the mountain and moor chapter.

Related Concerns

15.15. Seepages, streams and gullies often important sites for invertebrates and plants (e.g. Telfer, 2006;Whitehouse, 2007). Such features can create obstacles along coast paths, and may provide access down to beaches. When difficult (and even dangerous) for pedestrians to traverse or cross, drainage pipes or channelling are often put in place to enhance site safety. This can be deleterious to the invertebrate habitat.

16. COASTAL VEGETATED SHINGLE

Summary

- New material relating to this habitat highlights the vulnerability of coastal vegetated shingle to trampling, which has consequences for invertebrates and plants.
- Other more localised impacts include damage from the illegal small-scale extraction of shingle and compaction of shingle where boats are repeatedly pulled up onto the beach.
- Guidance on the management of access within this habitat advocates access management including set routes to minimise the area trampled.

Introduction and context

16.1. Coastal vegetated shingle was addressed within the coastal habitats chapter of the original guidance. We therefore simply provide an update here, drawing on material published post 2001.

16.2. The term ‘shingle’ has been used in Britain for at least 400 years to describe sediments composed of mainly rounded pebbles (2 - 200mm in size, Randall, 2004), and shingle accounts for some 30% of the English and Welsh coastline (Covey and Laffoley, 2002b). In its most common form, shingle occurs as a narrow band of beach material that supports strandline plant communities and occasionally builds to form major structures such as the barrier beach at Chesil, the cuspate foreland at Dungeness, and the spit at Orfordness. Six shingle sites within the UK are larger than 100 ha (Covey and Laffoley, 2002b).

16.3. The type of vegetation assemblages that may occur on shingle beaches is strongly influenced by stability, with the more complex communities present on the most stable sites. Five typical communities are recognised (Doody and Randall, 2003), ranging from unstable beaches, lacking vegetation to stable beaches with heath or grass-heath vegetation.

16.4. Stability of shingle habitats is a key element in determining the vegetation communities present. Succession typically leads to heath or scrub dominated communities (Figure 2), yet this succession can be set back by storms or surges which essentially set the system back.

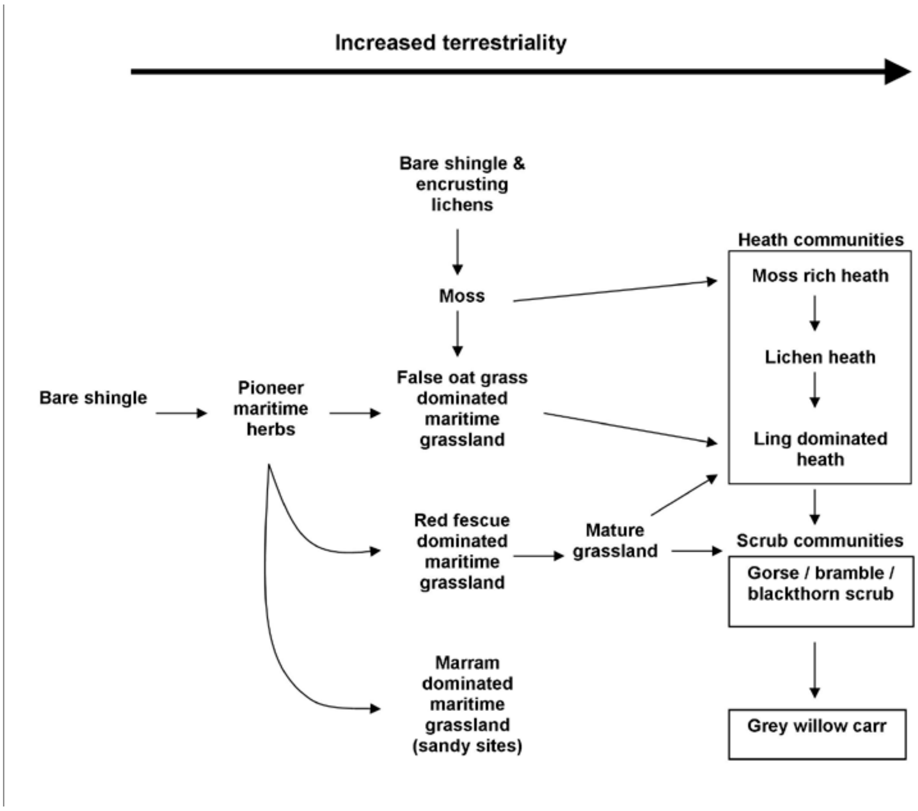

Figure 2: Summary of typical vegetation communities on shingle, adapted from Doody and Randall (2003).

16.5. The original guidance highlights a lack of research on the impacts of access to shingle habitats, with the small amount of research available showing that shingle vegetation is easily damaged and plant diversity reduced by trampling.

16.6. The principal source of new material since the original guidance is the work on management of coastal vegetated shingle (Doody and Randall, 2003;Randall, 2004). The guidance report (Doody and Randall, 2003) and associated case studies provide an authoritative overview of shingle habitats, key species, threats and management issues. Other new material includes a range of vegetation monitoring from the Sussex coast as part of the Beaches at Risk project (e.g. Fitzsimons *et al.*, 2007).

Accessibility of sites

16.7. While it is typically sandy beaches that receive the most visitors, some shingle sites do receive high numbers of visitors. The reserve at Rye Harbour is estimated to receive 150,000 visitors per annum, and Dungeness is visited by several million visitors annually (see relevant case studies, in the annex to Doody and Randall, 2003), at both these sites visitors are to nature reserves where access is actively managed. Browndown is a SSSI on the Solent, used by the MoD for military training and open to the public for informal recreation. Visitor monitoring on this site (Liley et al., 2006f) highlights a wide range of different types of visitor including dog walkers, fishermen, sunbathers, swimmers and naturists. Visitor rates at this location, during high summer, average in the region of eight people per hour. Dog-walking is one of the major activities and accounts for a high proportion of visits.

General vulnerability of sites

16.8. The most susceptible communities on shingle are those with abundant lichens. These are susceptible to trampling damage, especially in dry weather, when they are particularly easy to damage (Doody and Randall, 2003). Doody and Randall suggest that even the passage of one person walking (or cycling) on an established vegetated shingle ridge can “leave ‘footprints’, which may never be repaired”. In addition trampling results in compaction of the surface which affects the seed bank making it more difficult for some species to germinate. Where access management has taken place, such as control of visitors, flora can recover (Doody and Randall, 2003). At Orfordness in Suffolk biennial survey data of driftline vegetation, collected since 1996, has shown a recovery of the sea pea *Lathyrus japonicus* population that had largely disappeared from the site due to damage and disturbance caused by illegal access by vehicles and pedestrians. The recovery has coincided with the National Trust restricting access (see Orfordness case study in Doody and Randall, 2003).

16.9. At Browndown SSSI, small enclosures, established to protect the scarce flora, are effective, but where people are forced to walk round the fence, all vegetation has disappeared, creating rings of bare shingle around each exclosure (Liley et al., 2006f). Other impacts besides trampling at this site include litter, illegal fires (burning scrub and heath vegetation), eutrofication from dog fouling and disturbance to breeding birds (despite extensive suitable breeding habitat the number of breeding ringed plovers is very low, *pers. obs*). These issues are exacerbated by military training, with the site being used for beach landings. The work highlights the intense pressures that can be present on small sites surrounded by high human populations.

16.10. While large scale aggregate extraction is beyond the scope of this guidance, localised extraction can take place where public access occurs. This may be by individuals who remove small quantities for personal use or larger scale operations for sale (Doody and Randall, 2003). The extent of these activities is not known (Doody and Randall, 2003), and, if taking place within a SSSI not covered by common rights, such extraction is illegal.

16.11. Boat access on shingle beaches can cause damage and loss of vegetation, especially where boats are frequently pulled up the beach in the same location (Doody and Randall, 2003).

16.12. Mountain biking is only likely to occur on stable shingle areas, due to the difficulty in cycling on shingle. Any vehicle use on vegetated shingle can be very damaging, as even relatively minor incursions into the intact vegetated shingle ridges can break up the vegetation. Wheel tracks created by vehicles during the 1940s at Dungeness, for example, remain clearly visible today (Doody and Randall, 2003).

16.13. Doody and Randall (2003) advocate access management on shingle sites to minimise trampling levels. They suggest that interpretation and education materials are important and also advocate set routes to minimise the area walked over and boardwalks to allow people to walk across shingle areas without impact. Visitor exclosures, signage and wardening measures are all effective in reducing disturbance impacts where breeding terns or waders are present (e.g. Ikuta and Blumstein, 2003;Medeirosa et al., 2007).

Implications of research

16.14. Trampling of shingle is damaging to flora and invertebrates and set routes are recommended to minimise the area walked over and to minimise the area trampled.

Associated Interests

16.15. There are a number of ground nesting birds that can occur on shingle and for which there recent studies have shown clear impacts of disturbance. These include little tern and ringed plover (see birds chapter).

16.16. Shingle is an important invertebrate habitat, with a large number of rare or scarce species (Shardlow, 2001;Doody and Randall, 2003). Disturbance has an adverse impact on most species (Kirby, 2001;Shardlow, 2001), an example being the looping snail *Truncatella subcylindrica* (Alexander et al., 2005c). Further details are given in the invertebrate chapter (see paras 22.41 - 22.45).

Related Concerns

16.17. Dog fouling is an issue in this habitat, resulting in eutrophication (see the grassland chapter, paras 7.10 - 7.11).

17. COASTAL SALTMARSH

Summary

- Generally speaking, access to saltmarshes for normal recreational purposes does not represent a major problem. Saltmarshes are difficult to access and considered dangerous by many people, visitor rates are therefore comparatively low. Where access does occur it is often to access mudflats (for bait digging), access to boats or for samphie picking.
- The habitat does appear to be more robust than some other coastal habitats to trampling damage, however trampling does cause damage, directly affecting the saltmarsh vegetation. Any loss of vegetation cover carries with it the risks of erosion damage over a much wider scale.
- There are also issues relating to disturbance to birds and trampling of invertebrates. Disturbance to birds is relevant in both the breeding season and the winter. As access is typically along sea walls at the edge of the salt marsh, people at many sites will be clearly visible to any birds, even when on the very edge of the habitat.

Introduction and context

17.1. Although closely linked, we treat saltmarshes and mudflats as two separate chapters, in contrast to the original guidance, where both were lumped within the same heading within the coastal habitats chapter. We provide an update here, drawing on material published post 2001.

17.2. Saltmarshes form on the upper parts of intertidal mudflats where fine sediment is deposited by the sea and typically occur on sheltered coasts such as estuaries, inlets and behind barriers such as islands or shingle spits. Most of England's saltmarshes are concentrated in the major estuaries of eastern and north-west England, with smaller areas in the estuaries of the south coast. Because of variation in sediment type, saltmarshes on the east coast tend to comprise different species to those of the west coast (Covey and Laffoley, 2002b).

17.3. The majority of England's saltmarshes (some 32,500ha total area, Covey and Laffoley, 2002b) are protected as SSSIs and many are internationally important for birds. Loss of the habitat through coastal squeeze is a key issue (Cooper et al., 2001), the saltmarshes of south-east England have been eroding rapidly for about the last 50 years, at a continuing rate of about 40 ha year (Hughes and Paramor, 2004).

17.4. The original guidance found little material on access impacts to saltmarshes. It suggests that saltmarsh and their fauna are sensitive to trampling and gives evidence that plant species composition may change as a result of trampling. The difficulty of access on saltmarshes is highlighted.

17.5. New material includes a PhD thesis on climate change and coastal access that in part addresses saltmarshes (Coombes, 2007) and a saltmarsh review published by JNCC (Boorman, 2003). Another review (Doody, 2008) has a large chapter on conservation of saltmarshes but makes no reference to access or disturbance. Work from outside the UK that addresses access impacts includes a review of the ecology, disturbance and restoration of saltmarshes in Australia (Laegdsgaard, 2006) and a study addressing the impacts of off-road vehicles to saltmarshes (Kelleway, 2005).

Accessibility of sites

17.6. . For the majority of people saltmarshes are considered dangerous and inhospitable places which, even if they are appreciated, can be seen from the adjacent land .(Adnitt et al., undated). Visitor rates are therefore likely to be low.

17.7. The uses of saltmarshes include both direct ones such as wildfowling, bird-watching and walking, and indirect ones such as the use of the area for board- and dinghy-sailing during high water (Boorman, 2003). Access to mudflats, for example for bait digging, may involve people crossing saltmarsh habitats.

17.8. Visitor monitoring by Coombes (2007) explored the spatial distribution of different types of visitors at two locations on the north Norfolk coast. Coombes found that most visitors tended to avoid saltmarshes, walking around or between patches of marsh. There were, however, clear differences between types of visitors. Dog walkers and walkers used vegetated habitats, such as dunes and saltmarsh, to a greater degree than other users, whereas visitors relaxing, sunbathing, playing or paddling tended to use non-vegetated areas. Coombes also asked people about their preferences for different beach characteristics and two groups of visitors (dog walkers and birdwatchers) showed a weak preference for saltmarsh habitats. The saltmarsh at the study sites is not bisected by deep creeks and is relatively easy to walk across. Access levels onto saltmarsh habitats may therefore be dependent on the proportions of different types of visitors and the characteristics of the site.

General vulnerability of sites

17.9. Comparative studies of trampling impacts on different coastal habitats indicate that saltmarsh is the most resistant habitat, relative to sand dunes, coastal grasslands etc. (Andersen, 1995;Lawesson, 1998;Coombes, 2007). Although apparently more resilient, there is clear evidence of trampling impacts, as highlighted in the original guidance. One recent study has linked the decrease in the area of saltmarsh in parts of Australia to access (Laegdsgaard, 2006). Even annual visits to fixed sample points can cause visible changes to the vegetation (Boorman, 2003). The marshes which are the most liable to damage from trampling are those with poorly drained soils made up of fine sediments (Boorman, 2003). Pioneer saltmarsh may also be particularly vulnerable. Pioneer saltmarsh at Holkham is crossed by people visiting the beach, who fan out after crossing the dunes near a main access point. A clear network of bare paths is visible (Liley, 2008).

17.10. Trampling damage directly affects the saltmarsh vegetation. Any damage to the vegetation cover of the saltmarsh carries with it the risks of erosion damage over a much wider scale. It will also have an impact on the soil fauna with possible consequences for the functioning of the marsh ecosystem as a whole (Boorman, 2003).

17.11. There is little information on samphire *Salicornia europea* gathering (but see Adnitt et al., undated). The activity was apparently recorded in only 9 of the 155 estuaries covered by the Estuaries Review and there are no recorded impacts either on the vegetation or on other nature conservation interests from the current, low intensity activity associated with hand collection. By its nature, collection of the material can only take place at low tide and in the late summer, before the main wintering bird populations appear (Adnitt et al., undated).

17.12. Kelleway (2005) showed that vegetation cover, soil compaction, soil moisture, and mollusc and crab distributions were all adversely affected by off-road vehicle use (users included motorbikes, 4x4 vehicles and mountain bikes). In this Australian study the impacts were most severe in areas of high track density. Vehicle ruts and excavations were prone to waterlogging which had consequences for vegetation composition. Kelleway compared different saltmarsh communities, finding that rush-dominated communities generally showed less damage, due in part to morphological characteristics of the dominant plant species.

17.13. There is a large volume of work that addresses grazing of saltmarshes, including by horses (see Doody, 2008 for overview), and grazing is often important in maintaining the conservation interest of the habitat (e.g. Norris et al., 1997;Phillip S. Levin, 2002). While many of these studies address horse grazing, there is very little on the impacts of horse riding on saltmarshes. Most of the grazing studies do not differentiate between the impacts caused by livestock grazing action of the livestock, nutrient enrichment and trampling. Jedsen (1985) suggests that, when soil moisture is high, as in salt marshes, the trampling by grazing animals often leads to loss of soil structure. A study (Turner, 1987) simulated different aspects of grazing by clipping vegetation and mimicking trampling effects using a trowel. Trampling, but not clipping, independently reduced net primary production. The study, conducted in *Spartina*-dominated saltmarsh in the US, suggests that the trampling effect of grazing animals may have a greater impact than that of the actual grazing (the clipping of the vegetation). Trampling by horse riders may have a similar effect.

Implications of research

17.14. Trampling can reduce vegetation cover within saltmarshes. However, generally speaking, access to saltmarshes for normal recreational purposes does not appear to represent a major problem. Saltmarshes appear to be more resitant to damage from trampling than some other coastal habitats and, by their very nature, saltmarshes tend to not be subjected to high visitor pressure.

17.15. Where there are bird interests (either breeding or wintering) or rare invertebrates present then there may be a need to carefully assess access levels. People walking along the edge of saltmarshes (i.e. on sea walls) will often be conspicuous against the sky line and therefore disturbance to birds can be an issue even when access is not actually taking place within the marsh.

Associated Interests

17.16. Saltmarshes are important for breeding waders (such as avocet and redshank), roosting birds, invertebrates and some mammals. Disturbance to birds is a particular issue for this habitat, but we are not aware of any specific material for this habitat published since 2001.

17.17. Some invertebrates associated with saltmarshes are vulnerable to trampling (see paras 22.55 - 22.57).

Related Concerns

17.18. Access routes for saltmarshes are typically along sea walls. Future shoreline management, such as realignment, could have consequences for access routes and knock on consenques relating to disturbance and trampling.

18. MUDFLATS AND SANDY BEACHES

Summary

- New material relating to this habitat principally concerns impacts to invertebrates and is therefore addressed within chapter 22. Disturbance to birds is also relevant on many sites.

Introduction and context

18.1. In this chapter we address mudflats, sandflats and lower beach habitats. Mudflats were included in the saltmarsh chapter of the original guidance, but only given limited coverage.

18.2. Most mudflats are found within estuaries, the largest coastal habitat resource in England (Covey and Laffoley, 2002b). Outside estuaries there are muddy sediments wherever there is sufficient shelter from wave action, such as behind islands or towards the top of extensive intertidal flats. Mudflats support rich invertebrate communities, which provide an important food source for wading birds and fish. Surface plants such as sea grass or seaweeds such as gutweed *Enteromorpha* spp. help to stabilise the sediment, reduce erosion, and provide food for large numbers of birds.

18.3. Sand, rather than mud, is deposited where there is a lack of fine sediment or where there is greater wave action, ensuring only the larger sediment grains are deposited. Many sandy beaches are highly mobile, with sand being removed by storms and then re-deposited. Plants are unable to survive on highly mobile sandy beaches, however. Like mudflats, a specialised community of invertebrates and molluscs may occur, especially where the beach/flat is regularly inundated by the tide.

18.4. With increasing shelter, finer sediments are deposited, consisting of both sand and mud. These mixed sediments contain the most varied marine sediment communities (Covey and Laffoley, 2002b), characterised by diverse communities of worms such as lugworm *Arenicola marina* and ragworm *Nereis* sp., along with shells such as Baltic tellins *Tellina* sp.

18.5. There are 46 estuarine SSSIs covering 100,000 ha which predominantly comprise mudflat (Covey and Laffoley, 2002b). England has nearly 20% of Europe's Atlantic and North Sea estuaries, and many of the mudflats are internationally important for their birdlife.

18.6. The original guidance contains very little material on mudflats, referring in brief only to the work of Chandrasekara (Chandrasekara and Frid, 1996). There have been subsequent studies of the effects of trampling on mudflat invertebrates (Johnson et al., 2007;Rossi et al., 2007). There is also a suite of studies addressing vehicular and foot trampling of sandy substrates/lower beaches (Moss and McPhee, 2006;Schlacher et al., 2007b;Schlacher and Thompson, 2007;Barca-Bravo et al., 2008;Schlacher et al., 2008a;Schlacher and Thompson, 2008;Schlacher et al., 2008b;Ugolini et al., 2008). These impacts of trampling to invertebrates are addressed in the Invertebrates chapter (chapter 22).

Accessibility of sites

18.7. There is little new information. Generally these habitats are not subject to high visitor levels. On most sites access will be limited to people bait digging, harvesting shell fish or accessing boats at low tide. Regular mapping of bait diggers at one estuary on the south coast of England over a winter period demonstrates preference for certain areas of mudflat and, on exceptional low tides, large numbers of diggers present (Liley et al., 2008 in press). At Holkham, North Norfolk, it was visitors who were walkers or those relaxing, sunbathing, playing or paddling (in contrast to dog walkers and birdwatchers) who tended to walk on the lower (non vegetated) beach habitats (Coombes, 2007)

General vulnerability of sites

18.8. There is a large body of work addressing trampling impacts to infauna and surface invertebrates associated with these habitats (see paras 22.48 - 22.54).

18.9. There is a lack of work on the trampling effects of cycling or horse riding on mudflats or sandflats. Given that there is clear evidence for trampling impacts from pedestrians, cycling and horse riding might be expected to have similar impacts. There is evidence from Australia that crustaceans can be crushed by vehicles (Moss and McPhee, 2006;Schlacher et al., 2008b). The damage occurs both to animals on the surface and within their burrows, with all individuals in shallow burrows (5 cm depth) likely to be killed by 10 vehicle passes and 10–30% killed at 20 cm depth (Schlacher et al., 2007b). Macrobenthic assemblages on beaches where off-road vehicles are used had significantly fewer species at substantially reduced densities, resulting in marked shifts in community composition and structure (Schlacher et al., 2008a).

Implications of research

18.10. These are open habitats where people are highly visible. Access levels will usually be low. Implications of access for nature conservation will be site specific depending on the levels of access, type of substrate and species present.

Associated Interests

18.11. For both sandflats and mudflats there is evidence for loss of invertebrates from trampling (see paras 22.48 - 22.54). Beach cleaning is also a particular issue for invertebrates (see paras 22.45 and 22.53).

18.12. In such open habitats people are highly visible and disturbance to birds is also a key issue, addressed in the Birds chapter (chapter 19). Where trampling levels are sufficient to cause a reduction in prey density or alter community structure of invertebrates, there may also be consequences for birds. Various studies address the consequences of shifts in prey abundance for wading bird populations (Goss-Custard, 1980;Sutherland, 1998;Caldow et al., 1999;Stillman et al., 2001;West et al., 2002;Stillman et al., 2003). Reductions in prey abundance or size can greatly affect shorebird mortality and population size, and this effect can be greatly increased by periods of cold weather or when prey are unusually scarce (Stillman *et al.*, 2001).

Related Concerns

18.13. no additional material.

19. BIRDS

Summary

A large volume of research on the impacts of disturbance to birds has been published since 2001, much of it as a direct result of recommendations ensuing from the original guidance. Recent publications extend the knowledge base, both in terms of habitats and species. In some cases, researchers go beyond behavioural effects (the impacts most commonly studied) to examine the demographic and/or population impacts that are of greatest relevance for conservation.

We highlight the following key points, relating to how disturbance operates and studies of particular groups:

- Disturbance can be considered as a form of habitat loss, essentially meaning that areas of otherwise suitable habitat are not used. Disturbance can also result in a reduction in breeding success or survival.
- For heathland species there a large body of new work showing clear impacts of disturbance to Annex I breeding species. Disturbance can result in reduced breeding success (nightjars and Dartford warblers), lower densities (nightjar, woodlark) and flushing from the nest (nightjars and stone curlews)
- Golden plover and dunlin in the uplands have been shown to avoid areas adjacent to heavily used paths. The extent of this avoidance is dependent upon the extent to which people stick to the path.
- Reduced breeding success has been found for peregrines on cliffs where climbing takes place.
- Studies on inland waters show variations between species in how ducks respond to disturbance and variations in response to different types of disturbance.
- Disturbance by visitors to cliff-nesting seabird colonies has been shown to cause a reduction in breeding success. There is also new material on little terns, eiders and petrels.
- Beach nesting shorebirds have been the focus for a large volume of material, showing impacts of disturbance at a population level.
- For wintering waders, disturbance can have fitness consequences, with numerous small disturbances being of greater consequence that fewer, large events.

General Vulnerability of Breeding or Wintering Birds

19.1. In 2005 lead partners involved in the UK BAP were asked to report on their species and habitats (see Defra, 2006 for details). The reporting included identifying current or emerging threats. Disturbance issues (including infrastructure) were identified as threats for five bird species (Table 4).

Table 4: BAP priority bird species (from 2005) where disturbance or housing issues identified as a current or emerging threat. Two species (red-necked phalarope and capercaillie) where the breeding population is restricted to Scotland are omitted.

	Housing infrastructure	*Military use / disturbance*	*Other recreation / tourism*
Stone Curlew		✓	✓
Nightjar	✓		✓
Cirl Bunting	✓		
Woodlark	✓		✓
Grey Partridge			✓

19.2. Although post-2001 publications have considerably strengthened the evidence base concerning the effects of visitor access (and consequent human disturbance) on birds, it remains insufficient to enable the construction of a robust and thorough assessment of the likely significance of any impact of the introduction of a statutory right of access on wild bird populations as a whole. Moreover, available evidence suggests that the impacts of a given level of disturbance will vary in relation to species, site characteristics (such as availability of alternative, undisturbed areas), time of year, and degree of habituation. Generalisations are thus both impossible and potentially unhelpful. Further, caution should be exercised when extrapolating conclusions from one particular set of circumstances to another, even when the same species is involved. Nevertheless, data useful to conservation managers do exist, and this chapter summarises the key findings published since 2001.

Understanding the real impacts of disturbance to birds

19.3. Human disturbance to birds can be a very real problem and can have a surprisingly pronounced effect. A study of incubating hooded plovers *Thiornis rubricollis* on Australian beaches concluded that human disturbance was more frequent than natural disturbance, and that humans decrease nest attendance more than any other source of disturbance (Weston and Elgar, 2007). A study of birds along a reservoir shore in the US suggested that bird-species composition is regulated more by human activity than by plant-community composition (Francl and Schnell, 2002). When the time and energy costs arising from disturbance were included, disturbance could be more damaging for Eurasian oystercatchers *Haematopus ostralegus* than permanent habitat loss (West *et al.*, 2002).

19.4. Many previous studies have stressed the negative effects of recreational disturbance on bird behaviour and distribution and on breeding success (site-based and demographic perspectives, respectively). From a conservation viewpoint, however, it is the impact on population levels that is of greatest importance. A few recent studies have addressed this issue, and their findings are likely to be particularly relevant for conservation managers.

19.5. A wide range of methods have been used to assess the impact of human disturbance on wildlife. The choice of method depends on the particular circumstances and questions being asked (Table 5). .

Table 5: Examples of different measures of the impacts of human disturbance and the information gained from each. Taken from Gill (2007).

Effect of disturbance	*Information provided*
Change in distribution	
• Long term avoidance of areas with high levels of human activity	Site-based issues, e.g. reduced numbers on a site designated for a species
• Short term movement in response to human presence	Could indicate a site-based effect if movement is repeated or prolonged
Change in behaviour	
• Flight response • Increased vigilance • Altered incubation pattern	Could indicate either potential demographic costs or that individuals are responding because they can afford to, rather than because they are vulnerable
Change in demography	
• Reduced fecundity in a disturbed area • Reduced survival in a disturbed area	Reduced fitness of a particular group of individuals, e.g. may be importance for a species of conservation concern
Change in population size	
• Severe demographic changes causing population decline	Effect of disturbance on population status – may be most relevant for small populations
• Population decline as a result of densitydependent • changes to mortality or fecundity • following redistribution in response to disturbance	Effect of disturbance on population size and status Ability to predict population-scale responses to altered disturbance regimes

19.6. The site-based perspective highlighted by Gill (2007) often comprises an examination of whether the number of animals at a particular site is constrained as a result of human presence; it is particularly relevant to sites that seek or are legally obliged to maintain population numbers of a particular species. This approach is particularly appropriate if the use of key resources at the site can be quantified (Gill, 2007).

19.7. The demographic perspective usually seeks to determine the impact of changes in behaviour arising from disturbance on species' fitness levels or breeding productivity. However, it is often impossible to differentiate between animals that do not respond to disturbance because they are not affected by it and those that do not respond because they have no alternative, but suffer severe costs as a result. The opposite may also be true: that it is impossible to distinguish between species that move following disturbance because the costs of doing so are negligible (e.g. because there is an alternative good foraging area nearby) or those that move because the costs of staying are even greater than those involved in moving. That opposing circumstances can have the same effect means that simple behavioural responsiveness to disturbance is insufficient to determine actual vulnerability to human presence; instead, the fitness consequences of disturbance must be determined—but few studies so far have done so (Gill, 2007).

19.8. Demographic (fitness) consequences of human disturbance are clearly important at the level of individual animals. However, whether the consequences translate into population-scale impacts depends on the scale at which disturbance occurs and the impact of conditions at the site to which animals have moved in response to disturbance and the consequent impacts of density dependence (Gill, 2007). For example, breeing ringed plovers avoid otherwise suitable areas of habitat when access levels are high, (Liley, 1999), and through an understanding of density-dependence and the spatial distribution of people a finding that enabled the calculation of the population impact of visitor numbers and distribution (Liley and Sutherland, 2007). Recent work on woodlarks (Mallord, 2005;Mallord et al., 2007a) and Dartford warblers (Murison, 2007;Murison et al., 2007) has similarly found that population-scale changes relate to density dependence as well disturbance impacts. Where possible, conservation management decisions should thus be based on an understanding of the density-dependent consequences of avoidance of disturbed areas (Gill, 2007).

19.9. From a conservation viewpoint, the impact on population levels is of greatest importance. Conservation managers need to consider whether the conservation benefits of public access at a site might outweigh population consequences for particular species, i.e. whether it is in the species' overall net interest to take a site-specific 'hit' (Beale and Monaghan, 2005;Mason, 2005;Gill, 2007). Unfortunately, there seem to be no easy answers, as research suggests that the optimum solution is likely to be both site- and species-specific (Yorio et al., 2001;Mason, 2005;Gill, 2007). Modelling the consequences of alternative access scenarios is necessary to help policymakers and management decision makers develop appropriate mitigation measures (Mallord et al., 2007a;Mallord et al., 2007c).

Generic behaviour impacts of disturbance on birds

19.10. In general, the presence of people can cause changes in feeding behaviour (Verhulst et al., 2001;Thomas et al., 2003b), cause birds to take flight (Fernandez-Juricic et al., 2001;Blumstein, 2003;Blumstein et al., 2003 ;Fernandez-Juricic et al., 2005;Webb and Blumstein, 2005), provoke unnecessarily increased vigilance that diverts attention away from 'real' predators (Fernandez-Juricic and Schroeder, 2003;Randler, 2006), or cause birds to temporarily or permanently avoid areas perceived as being of high risk (Finney et al., 2005;Liley and Sutherland, 2007).

19.11. Specific examples of behavioural responses include the temporary avoidance of the area around a footpath in the Pennines by golden plovers and dunlins (Pearce-Higgins *et al.*, 2007); changes in feeding behaviour of Eurasian oystercatcher (Verhulst et al., 2001;Coleman et al., 2003) and sanderling *Calidris alba* (Thomas *et al.*, 2003b) and flushing of incubating stone-curlews (Taylor *et al.*, 2007) or nightjars (Langston et al., 2007c).

19.12. Barking dogs and other potential predatory threats cause common coots *Fulica atra* to increase vigilance behaviours, which diverts attention away from foraging, resting or scanning for 'real' predators (Randler, 2006). Disturbance to Eurasian teal prompted temporary movements away from the disturbance source and diverted birds from resting to foraging (Guillemain *et al.*, 2007). Regular disturbance may either result in habituation and thus increased tolerance levels, or in increased sensitivity and flushing at greater distances, as with black grouse (Richardson and Baines, 2004;Baines and Richardson, 2007).

19.13. Research supports the evolutionary insight that disturbance stimuli are analogous to predation risk. Birds often respond to human disturbance as they would to potential predators (Frid and Dill, 2002;Finney et al., 2005), leading to the consideration that people may inadvertently act as ‘predation-free predators’ even if they pose no direct mortality risk to either adults or young birds (Beale and Monaghan, 2004b). Predation and non-lethal disturbance stimuli create similar trade-offs between avoiding perceived risk and other fitness- enhancing activities such as feeding, parental care or mating. Prey that have detected a potential predator should make optimal fleeing decisions that balance the benefits of reducing capture probability against the costs of abandoning a resource patch and expending energy on locomotion (Frid and Dill, 2002).

19.14. It follows that human recreational activities restrict, in time and/or space, animals’ access to resources that they would otherwise exploit (Gill, 2007). This can either comprise direct restriction of access (e.g. to food supply, nest-sites, roost-sites) or alteration of the actual or perceived quality of a site (e.g. through attracting predators or reducing the presence of prey). Inability to garner sufficient energy reserves can reduce survival rates, particularly in migratory birds needing to build up large fat deposits prior to a long journey (Gill, 2007). Disturbance may also affect the spatial and temporal patterns of resource exploitation as a result of reduced habitat quality, for example following trampling (Frid and Dill, 2002).

19.15. Not all research demonstrates perceptible impacts of disturbance on behaviour. Studies on golden eagle (Whitfield *et al.*, 2007) and black-tailed godwit (Gill *et al.*, 2001a) revealed no apparent impact, although both investigations were thought to be rather limited in scope (Woodfield and Langston, 2004a).

Physiological impacts of disturbance on birds

19.16. Physiological impacts on individual birds may occur, such as changes in the levels of stress hormones (Tempel and Gutierrez, 2003;Walker et al., 2006), heart rate (Weimerskirch et al., 2002;Beale, 2007) or metabolic rate (Stillman *et al.*, 2007). The level of response shown by a bird may depend on the stress that the individual is already under (Stillman and Goss-Custard, 2002). Habituation has been reported to reduce stress responses (Walker *et al.*, 2006). The fitness and long-term consequences of stress responses are difficult to measure (Walker *et al.*, 2005).

19.17. It is conjectured that birds subject to disturbance exhibit anti-predator physiological responses (e.g. increased heart rate or increased metabolic requirements) which may cause their condition to decline rapidly, in turn increasing the likelihood of brood desertion or reducing survival (Beale and Monaghan, 2004b).

Beyond behavioural impacts: demographic and population effects

19.18. Recent research has moved beyond the consequences of disturbance for behaviour to the consequences for fitness levels/demographics and for populations, although studies remain relatively few. For nature conservation managers to decide whether to introduce visitor-related management actions or invoke the special restrictions provided under CRoW, research needs to establish whether disturbance responses are biologically important, by reducing fitness costs or breeding success rates (demographic effect), by reducing numbers of the study species at the site in question (population effect) (Drewitt, 2007;Langston et al., 2007a;Liley, 2007), or by adversely affecting the favourable conservation status of a site protected for nature conservation (Pearce-Higgins *et al.*, 2007)

19.19. Demographic impacts of disturbance potentially include reduced breeding success (Murison, 2002;Bolduc and Guillemette, 2003;Beale and Monaghan, 2004b;Beale and Monaghan, 2005); avoidance of otherwise suitable breeding habitat (Taylor *et al.*, 2007); later nesting in the breeding season (Richardson and Baines, 2004;Baines and Richardson, 2007;Murison et al., 2007); reduction of adult foraging time and allocation of prey to chicks (Verhulst *et al.*, 2001) and reduction in fitness of wintering birds (Stillman and Goss-Custard, 2002;Goss-Custard et al., 2006).

19.20. Some studies have looked for demographic impacts and failed to find them. For example, for golden plovers nesting by the Pennine Way footpath breeding success did not decline with visitor disturbance. This was thought due to the species sitting tight on the nest while incubating and having long daylight hours in which to compensatorily forage to provision chicks (Pearce-Higgins *et al.*, 2007). For woodlarks on Dorset heaths, high disturbance levels were considered to produce a strong density-dependent increase in reproductive output such that pairs raised more fledglings in disturbed areas (Mallord et al., 2006;Mallord et al., 2007a). For other species showing similar lack of visitor impact on breeding success, such as Eurasian dotterel (Woodfield and Langston, 2004a) and lapwing (Fletcher *et al.*, 2005), other environmental factors are or are probably more significant. For eight shorebird species wintering on the Wash estuary, disturbance was not considered to threaten survival (West *et al.*, 2002).

19.21. Birds may be able to compensate for the effects of disturbance, such as by moving to undisturbed areas or by compensatory feeding (e.g. at night when human disturbance is generally lower). However, if individuals or populations are already under pressure (e.g. when building up energy reserves prior to migration or actual scarcity, respectively), disturbance may have a disproportionate effect on individual survival, demographic characteristics such as breeding success, and population size (Woodfield and Langston, 2004a), all of which may not be perceptible within the confines of a particular research project (e.g. because of the project's geographical or temporal constraints).

19.22. Little work has been done to move from the impact of disturbance on individual birds or groups of birds to the consequences of disturbance for populations—but nevertheless more is available now than in 2001. For example, disturbance-specific population modelling has now been conducted for ringed plovers *Charadrius hiaticula* (Liley and Sutherland, 2007), oystercatcher (West et al., 2002) and woodlark *Lullula arborea* (Mallord et al., 2006;Mallord et al., 2007c).

Disturbance effects on breeding birds

19.23. Many studies have shown that birds are deterred from breeding in areas with large numbers of people (Woodfield and Langston, 2004a). Breeding birds are assumed to be potentially highly susceptible to disturbance, either because of direct reductions in breeding productivity or limited opportunity for relocation without abandoning the breeding attempt (Woodfield and Langston, 2004a).Disturbance may affect birds in different ways at different stages in the breeding cycle (Woodfield and Langston, 2004a):

- Visitor distribution may reduce the area of available breeding habitat (Finney *et al.*, 2005);
- Birds may be dissuaded from establishing territories or feel forced to breed in sub-optimal territories: if sites are limited, population size may be restricted (Woodfield and Langston, 2004a);

- Disturbance of incubating birds may lead to the bird leaving the nest, this reduction in nest attentiveness meaning that its eggs become more vulnerable to predation or adverse weather, both of which may reduce breeding success (Murison, 2002;Woodfield and Langston, 2004b). In theory, this risk should reduce with proximity to hatching, as parents are more wedded to their greater energetic investment;

- Clutch destruction may result from trampling, handling, deliberate destruction or predation by dogs. Reduced breeding productivity could have population consequences (Woodfield and Langston, 2004a);

- Much research shows that disturbance during the brooding period reduces chick foraging and/or provisioning. However, there is no clear evidence as to the impact of this on chick survival – or on subsequent breeding success when the young birds reach sexual maturity (Woodfield and Langston, 2004a;Finney et al., 2005).

Disturbance effects on wintering birds

19.24. During the non-breeding season, the main impacts of human disturbance on birds are interruption to foraging and, to a lesser extent, roosting (Woodfield and Langston, 2004a). There is a body of research suggesting that responsiveness to disturbance is a species-specific trait (Yasué, 2005). The extent to which disturbance affects the actual distribution of birds within a site will vary according to the species, the availability of other resources and the birds' own state. If birds are under stress, for example during cold winter weather when food resources are scarce, they may be less obviously disturbed than at other times (Stillman and Goss-Custard, 2002;Burton, 2007).

19.25. There may also be seasonal variation in a species' responsiveness to disturbance, as individuals alter their threshold in response to shifts in the basic trade-off between increased perceived predation risk (tolerating disturbance) and the increased starvation risk of not feeding, i.e. avoiding disturbance (Stillman and Goss-Custard, 2002). Towards the end of winter, migratory birds need to increase feeding rates to provide energy for migration to breeding grounds. As winter progresses, Eurasian oystercatcher energy requirements increase and their feeding conditions deteriorate. To survive they spend longer feeding and so have less spare time in which to compensate for disturbance. Later in winter, birds approach a disturbance source more closely and return more quickly after a disturbance. Their behavioural response to disturbance is less when they are having more difficulty surviving and hence their starvation risk (avoiding disturbance) is greater (Stillman and Goss-Custard, 2002). It is thus important to measure subtle behavioural changes in foraging rates along with key ecological variables in order to assess the true impact of human disturbance on migratory shorebirds (Yasué, 2005).

19.26. It should be noted that the body of evidence on the impacts of disturbance on breeding birds is considerably larger than that available for wintering birds. Given that the UK holds internationally important wintering populations of many species and the quality of the wintering sites can have implications for breeding success (Gunnarsson et al., 2006), this balance might be worth redressing. Studies might be commissioned on the effect of disturbance on significant species; specific recommendations (e.g. for white-fronted goose *Anser albifrons*, whooper swan *Cygnus cygnus*, grey plover *Pluvialis squatarola* and bar-tailed godwit *Limosa lapponica*) are given in a recent review of future research priorities (Liley, 2007).

Lowland Heathland

19.27. The original guidance (chapter 12.6) identified heathland as being of special concern due to the small and fragmented nature of remaining habitat, and the presence of nationally or internationally important populations of scarce bird species. Accordingly, heathland has been disproportionately well represented in bird–disturbance research published since 2001, with important publications on four key species: stone-curlew (Taylor *et al.*, 2007), nightjar (Liley and Clarke, 2002b;Liley and Clarke, 2002a;Murison, 2002;Liley and Clarke, 2003;Clarke et al., 2006;Langston et al., 2007c;Langston et al., 2007d;Clarke et al., 2008a), woodlark (Mallord et al., 2006;Mallord et al., 2007a) and Dartford warbler (Murison, 2007;Murison et al., 2007).

19.28. A clear relationship has been demonstrated between disturbance resulting from visitor access and the breeding success or density of European nightjars (Langston et al., 2007c), woodlarks (Mallord *et al.*, 2007c) and Dartford warblers (Murison, 2007;Murison et al., 2007). Although nightjar and woodlark populations have increased in recent years, prospects for further recovery may be limited by factors including the effects of recreational disturbance (Langston et al., 2007d). Dogs present a particular threat: visitors to heathlands are apparently more likely to let their dogs off the lead (89–100%) than in any habitat other than sand dunes (Underhill-Day and Liley, 2007). Mallord's (2007) modelling of the population impacts of various disturbance levels demonstrates the utility of applying such models to different future access scenarios to assist with planning and management of access and conservation (Langston et al., 2007a).

19.29. Various management measures have been suggested to minimise the adverse effects of disturbance on this trio of species, particularly at sites where high access levels coincide with high concentrations of breeding birds (Woodfield and Langston, 2004a;Langston et al., 2007c). The CRoW provision for dogs to be kept on a fixed lead of no more than 2 m length during the bird breeding season (normally 1 March–31 July) should be enforced. Provision could be made for off-lead dog exercising areas in non-sensitive areas. Reducing the penetrability of path-side habitats could be used as a management tool to influence access patterns, especially at path margins; dogs appear to range off paths less frequently or even never when they encounter gorse (Langston et al., 2007c;Murison et al., 2007). The attractiveness of particular heathland routes to different user categories (e.g. dog-walkers) could be changed (Underhill-Day and Liley, 2007). Car parks, access points and footpaths could be positioned away from areas used by breeding nightjars and Dartford warblers, or their size, character or nature changed (Underhill-Day and Liley, 2007). Other measures include temporary path closures and diversion of paths away from sensitive areas (e.g. those with high densities of avian interest features) and provision of information to visitors. Management action is easier at sites where staff are present (Langston et al., 2007c). For Dartford warblers, it has been suggested that heather territories adjacent to open recreational areas such as lawns, access points and car parks need particular management attention (Murison, 2007;Murison et al., 2007).

19.30. Reviewing work examining the impact of disturbance by humans on foot on heathland birds, Woodfield and Langston (2004) suggest measures for sites where high access levels coincide with concentrations of breeding birds of conservation concern (e.g. the Annex I trio): keeping people and dogs on paths, enforcing the requirement for dogs to be kept on leads during the breeding season (combined with a programme of information and education), planting vegetation such as gorse (*Ulex* sp.) along pathsides to make straying off-path more difficult, assigning areas for recreational activity away from areas for walking and quiet enjoyment, and considering access restrictions in areas where concentrations of breeding nightjars coincide with high visitor levels.

19.31. Communal winter roosts of scarce raptors, especially hen harrier *Circus cyaneus* but also merlin *Falco columbarius* are noted as a heathland feature in the original guidance. Traditional roost sites are identified as places where access management measures, or exclusions/restrictions, should be implemented in relation to CRoW (Brown and Langston, 2001). There is some anecdotal evidence that raptor roosts may be abandoned as a result of disturbance. A well-known hen harrier roost site in Dorset was abandoned in 1997, with local counters believing that increased access by walkers and other recreational activities was the cause. The site was a slope with dense heather and no tracks or footpaths, apart from a single bridleway, popular with dog walkers and other users (Liley *et al.*, 2002).

Stone-curlew *Burhinus oedicnemus*

19.32. Much stone-curlew *Burhinus oedicnemus* breeding habitat in England is designated as open-access land under CRoW. This species appears to be more sensitive to disturbance than some other wader species studied, even responding to disturbances at distances as high as 500 m (Taylor *et al.*, 2007), and thus restriction of access has been applied to breeding stone-curlews more frequently than for any other reason (Bathe, 2007).

19.33. The probability of stone-curlew site occupancy drops steeply even at low disturbance levels (less than one per hour) near to a nest site. The species is particularly vulnerable to disturbance when settling on plots in spring (20 March–20 April). The probability of an active response varies with the type of disturbance; controlling for distance, stone-curlews are more likely to run or fly following disturbance by a dog-walker than a walker without a dog (Taylor *et al.*, 2007). Stone-curlews tend to breed at sites where recreational access is historically low, shunning sites such as Stonehenge and RAF Barnham that have suitable habitat but high levels of human disturbance (Woodfield and Langston, 2004a). Disturbance is thus considered to potentially limit stone-curlew population recovery by preventing settlement in otherwise suitable habitat (Langston et al., 2007b).

19.34. Access exclusions apply to areas occupied by stone-curlews during March to October, reflecting their long breeding season (Langston et al., 2007a). An assessment of the significance of a statutory right of access to wild bird populations placed particular emphasis on 15 stone curlew breeding sites in Breckland and suggested that access should be restricted in view of the very low population and localized distribution (Brown and Langston, 2001).

19.35. To guide management decisions seeking to marry the dual aims of stone-curlew conservation and visitor access, a software package called the Stone-curlew Access Response Evaluator (SCARE) has been developed. SCARE offers a user-friendly tool to assess the effects on stone-curlews of scenarios for future changes in disturbance dynamics. The impacts of different access patterns, routes and users, as well as various mitigation measures can be modelled using real nest location data or proposals for the creation of artificial nesting plots (Taylor *et al.*, 2007). The tool will assist land managers to identify where footpath diversions may be necessary and to target stone-curlew enhancement measures away from particularly popular access areas (Langston et al., 2007a). Although SCARE is currently a single-species tool, it provides a framework by which other species could be assessed should suitable data be available for modelling (Taylor *et al.*, 2007).

European Nightjar *Caprimulgus europaeus*

19.36. Several recent studies have demonstrated a clear link between human disturbance and both population densities and breeding success in European nightjars *Caprimulgus europaeus* (Liley and Clarke, 2002b;Liley and Clarke, 2002a;Murison, 2002;Liley and Clarke, 2003;Clarke et al., 2006;Langston et al., 2007c;Langston et al., 2007d;Clarke et al., 2008a).

19.37. An assessment of visitor access effects and housing on European nightjar *Caprimulgus europaeus* numbers concluded that the population on the Dorset Heaths and Thames Basin Heaths Special Protection Areas would be 14% higher were there no housing or visitor pressure (Clarke et al., 2008a). On the Thames Basin Heaths, nightjars demonstrate a general preference for areas away from access points and from site edges, and there is a trend for nightjar density to decline with increasing visitor pressure with nightjars appearing to avoid areas of high disturbance within sites. This decline is gradual, and there is not a clear cut-off point at which a marked change in nightjar density occurs. The trend is similar but much less clear on the Dorset Heaths (Liley et al., 2006a;Langston et al., 2007d). However, a negative correlation was shown on the Dorset Heaths for urban development or people density and nightjar density, whatever the size of heathland studied (Liley and Clarke, 2002a;Liley and Clarke, 2002b); urban development density in this case could be considered a rough proxy for recreational access levels.

19.38. Studies on ten Dorset heaths revealed that nightjars had significantly higher breeding success at sites with no public access than those with open access. Nests had a greater chance of failure on open access sites with more surrounding urban development and increasing proximity to a greater density of footpaths (Murison, 2002). Nightjar nests that failed were significantly closer to paths (45 m compared to 150 m for successful nests) and tended to be closer to the main access points. Nightjar territories had fewer paths within 100 m than did random points. No significant differences in levels of path usage and nest failure were detected. Incubating nightjars sit tight unless disturbed: in 2,000 hours of camera observations of eight nests, nightjars never left the nest unattended during the day unless disturbed (Langston et al., 2007a).

19.39. Human and dogs flush nightjars from their nests, the flushing rate being positively associated with height of the vegetation around the nest (presumably because nightjar cannot see the cause of the disturbance) and negatively correlated with the extent of nest cover (Murison, 2002;Langston et al., 2007a;Langston et al., 2007d). Flushing during daylight leaves nightjar eggs or chicks vulnerable to predation, the proximate cause of nest failure (Mallord *et al.*, 2007a). In the single documented instance, the predator was a carrion crow *Corvus corone*, but this species may be responsible for 60% of nest failures (Murison, 2002).

19.40. Most nightjar breeding failures happen during incubation (Murison, 2002;Woodfield and Langston, 2004b), and a single dog running off-path into the heather could disturb large areas of nightjar breeding habitat. Disturbance may be of greater significance during breeding seasons that, for other reasons (e.g. weather) are less favourable. A synergistic relationship is also likely, with flushing events presumably more likely to result in nest failure during cold, wet weather that induces the eggs to chill rapidly.

Woodlark *Lullula arborea*

19.41. Across 16 sites in southern England, including the Dorset Heaths, woodlark *Lullula arborea* population density was significantly lower at sites with higher disturbance levels (Mallord et al., 2006;Mallord et al., 2007a), which supported previous findings that density of woodlark territories is significantly reduced on sites with open access compared to those with restricted access (Liley and Clarke, 2002b). This pattern was thought to be due to birds not nesting (but nevertheless still foraging) in the most heavily visited areas.

19.42. At sites with recreational access, woodlarks were found to be less likely to colonise suitable habitat in areas with greater disturbance; eight disturbance events per hour reduced the probability of colonisation to below 50%. However, the lower woodlark density at more highly disturbed sites resulted in greater breeding success, in terms of more fledged chicks per pair, i.e. high disturbance levels produced a strong density-dependent increase in reproductive output (Mallord et al., 2006;Mallord et al., 2007a)

19.43. Using artificial woodlark nests, a positive correlation between nest predation and human visitor levels was found in Dorset, indicating that predation risk may increase at a site as human activity increases (Taylor, 2002;Langston et al., 2007c). Taylor found significant relationships between corvid activity and nest predation, and between human activity levels and corvid numbers. Thus, as human activity increases, the presence of nest-predatory corvids increases (Taylor, 2002), and thus woodlark breeding success would be expected to fall.

19.44. A model has been developed to predict the consequences for the woodlark population of a range of visitor access levels (Mallord *et al.*, 2006). Recreational disturbance is thought to already be having a major adverse effect on woodlark populations. Any further population impact is predicted to depend on spatial distribution of visitors as well as overall numbers. Under current access arrangements, a doubling of visitor numbers is predicted to reduce population size by 15%, while doubling visitor levels but spreading them equally across sites would result in a 40% population decline (Mallord et al., 2006;Mallord et al., 2007c). If disturbance at 16 heathland sites were to be removed, it was predicted that the breeding population of woodlarks would increase by 13–48% (Mallord 2005). Similar modelling of alternative access scenarios will be helpful for conservation management decision-makers (Mallord *et al.*, 2007c)

Dartford warbler *Sylvia undata*

19.45. Initial analysis based on data from the Dorset heaths suggested there was no statistically significant difference in the number of Dartford warbler *Sylvia undata* territories on sites with open access compared to those with restricted access (Liley and Clarke 2002). Subsequent studies, however, have refined this view. Clear impacts on breeding ecology have been demonstrated. Disturbance at territories was higher where these were located close to car parks (Murison, 2007;Murison et al., 2007). The species is particularly susceptible to disturbance when nest-building, halting or even abandoning activities when interrupted (Murison, 2007;Murison et al., 2007). The nearer the centre of the warbler territory is to an access point (e.g. car park), the later the first brood is likely to be raised. Disturbance thus appears to delay hatching dates and thus prevent chick growth from coinciding with periods of optimal invertebrate prey density, and also to interrupt adult foraging and chick feeding (Murison, 2007;Murison et al., 2007). Dog-walkers accounted for 60–72% of all disturbance events, with dogs off-lead and off-path likely to have the greatest adverse impact on Dartford warbler breeding productivity (Murison, 2007;Murison et al., 2007). Moreover, for such a short-lived species, in which there is also low over-winter survival of young birds, increased disturbance could limit population recovery by reducing annual breeding productivity and hence the numbers of potential recruits to new areas (Langston et al., 2007a).

19.46. Research on Dartford warblers shows that disturbance may impact on a single species to different extents in different habitats (Murison, 2007;Murison et al., 2007), a finding that may have applicability to other species. Dartford warblers occupy territories dominated by heather *Calluna vulgaris*, heather territories with significant areas of European gorse *Ulex europaeus* and territories containing Western gorse *U. gallii*. However, only in the first habitat type did disturbance have significant impact on breeding productivity, delaying breeding by up to six weeks which, in turn significantly reduced the number of broods raised and the average number of chicks raised per pair. In heather territories, an average of 13–16 people passing through per hour each day delayed pairs sufficiently to prevent them raising multiple broods; most heather territories fell below this threshold. The lower impact of disturbance in territories with gorse may be due to this impenetrable habitat offering protection from disturbance, as it is known to provide from harsh weather and predators. Dogs were seen to move up to 45 m off-path in heather, but never into gorse-dominated vegetation (Murison, 2007;Murison et al., 2007).

19.47. These findings have importance for Dartford warbler management (Murison, 2007;Murison et al., 2007), which are discussed in the *Heathland* section below.

Scarce heathland passerines in the winter

19.48. While the impacts of visitor access on heathland specialists such as woodlarks and Dartford warblers has been studied during the breeding season, no research has been conducted on the impacts of access during the winter on these predominantly sedentary species. However, it has been suggested that winter disturbance may affect these birds' foraging rates and survival, potentially working in conjunction with threats such as hard weather or wild fires (Underhill-Day and Liley, 2007).

Mountain and Moor

Upland-breeding waders

19.49. Information has recently been published on the impact of disturbance on four species of ground-nesting wader that breed in English uplands: golden plover *Pluvialis apricaria*, Eurasian dotterel *Charadrius morinellus*, dunlin *Calidris alba* and lapwing *Vanellus vanellus*.

19.50. In the Pennines, golden plovers guarding chicks utilise heavily disturbed habitat at a lower rate than surrounding areas. When 30% of walkers strayed from an unsurfaced and poorly maintained Pennine Way footpath, the movement of people across the moorland was widespread and unpredictable. In consequence, golden plovers avoided areas within 200 m of the footpath during the chick-rearing period. However, once the footpath was surfaced, only 4% of walkers strayed from the path, and golden plovers only avoided areas within 50 m of the footpath (Finney *et al.*, 2005). This reduced rate of avoidance occurred despite a doubling in visitor numbers (Pearce-Higgins and Yalden, 1997;Finney et al., 2005). Resurfacing of the path thus significantly reduced the impact of recreational disturbance on golden plover distribution.

19.51. As a ground-nester, it might be expected the golden plover breeding success would diminish close to heavily disturbed areas. However, studies in the Pennines revealed no evidence that golden plover breeding success was reduced close to a footpath used by 120 visitors per weekend-day. This may be explained by two findings: that golden plovers are more tolerant of disturbance when incubating than when chick-raising, tending not to flush from the nest; and that while breeding season disturbance reduces potential chick-feeding time, the temporal concentration of human visitors from 09h00–18h00 means that there are nine disturbance-free daylight hours available for foraging during chick-raising weeks (Pearce-Higgins *et al.*, 2007).

19.52. Also in the Pennines, dunlins showed a non-significant increase of 50% in habitat utilisation following provision of a surfaced footpath (Pearce-Higgins *et al.*, 2007). Together, these studies show that high levels of disturbance can impact on habitat usage by upland-breeding waders, but only where visitor pressure is high (defined as more than 30 visitors per weekend day), and suggest that the implementation of simple measures to influence visitor behaviour (e.g. a well-surfaced route) can dramatically reduce the impact of recreational disturbance on wild animal populations while enabling access by large numbers of visitors (Finney et al., 2005;Pearce-Higgins et al., 2007).

19.53. In contrast to the findings on golden plover and dunlin, there was no significant correlation between human disturbance (on- or off-path) and either Eurasian dotterel breeding success in Scotland (Whitfield study quoted in Woodfield and Langston, 2004a) or lapwings breeding in Durham (Fletcher *et al.*, 2005). However, lapwing clutch failure was lower in meadows than in pastures, the latter having shorter vegetation offering less nest concealment and having a greater density of potentially predatory and kleptoparasitic black-headed gulls *Larus ridibundus* (Fletcher *et al.*, 2005). Dotterels are exceptionally rare breeders in England, but 90% of lapwings in England and Wales breed on farmland, particularly hill farmland adjacent to or part of moorlands..

Breeding birds of prey

19.54. A study of cliff-nesting peregrines *Falco peregrinus* in the Alps revealed that breeding success and productivity were lower for pairs co-existing either with ravens *Corvus corax* or human disturbance by rock-climbers, compared to undisturbed pairs. In addition, pairs settled at cliffs simultaneously occupied by ravens and frequented by climbers did not fledge any young, suggesting that raven predation on peregrine eggs/chicks may be predisposed by human disturbance (Brambilla *et al.*, 2004).

19.55. Golden eagles *Aquila chrysaetos* were omitted from consideration in the original guidance (i.e. not in Appendix 7). Research on golden eagles in Scotland is likely to be transferable to this species' tiny English population. Surprisingly for a species generally perceived as susceptible to disturbance, researchers found little evidence to suggest that recreational disturbance influenced territory occupation, although some local effects may have occurred and further analyses are warranted (Whitfield *et al.*, 2007).

Black grouse *Tetrao tetrix*

19.56. The black grouse *Tetrao tetrix* was identified as one of a key group of bird species that may be affected by the implementation of open access (Liley, 2001), as the species inhabits moorland and its fringes, habitats integral to the new access regime. In an experiment in the Pennines, various levels of disturbance did not appear to impact fecundity—although disturbed females tended to lay five days earlier—presumably because birds were able to compensate for the impacts of disturbance by moving to less disturbed areas or perhaps by increasing their food intake rate (Richardson and Baines, 2004;Baines and Richardson, 2007).

19.57. The same authors also investigated the actual impact of disturbance frequency on radio tagged grouse (Richardson and Baines, 2004;Baines and Richardson, 2007). Birds that were disturbed more regularly flushed at greater distances. This was particularly the case in spring and winter, when birds flock together and feed on heather at favoured locations, when birds subject to "high" levels of disturbance (disturbed twice per week) flushed at 32% greater distances. However, the level of disturbance did not appear to impact on survival rates.

19.58. There is thus no clear evidence that increased human access to the North Pennine uplands will impact negatively on black grouse. Unfortunately the study was limited in that the levels of experimental disturbance were very low and limited in type (for example no dogs off leads). The authors suggest that there would need to be a twenty-fold increase in the numbers of walkers to create an impact equivalent to their higher disturbance category.

19.59. Work in the European Alps has found lower densities of displaying grouse in the spring in areas associated with winter sports (skiing, snow-shoeing and snowboarding) (Patthey et al., 2008).

Lowland Grassland

19.60. Stone curlews are associated with calcareous grassland habitats in the south-west. There is much new material on disturbance to this species, and this is covered in the heathland chapter (see paras 19.32 - 19.35).

Woodland

19.61. Many species of woodland bird have declined in the UK, and there is concern regarding the conservation status of a range of species. The reasons for the declines are complex and vary between species, disturbance does not seem to be implicated (Fuller, 2001;Fuller et al., 2005;Amar et al., 2006;Fuller et al., 2007;Gregory et al., 2007;Hewson et al., 2007)

Open Water

Wildfowl wintering on inland waters

19.62. An assessment of the consequences over time of disturbance to wintering wildfowl in a French wetland suggests that human disturbance through ecotourism has only very short term effects—and that these may be addressed by appropriately guiding visitors and providing appropriate facilities (Guillemain *et al.*, 2007). In the short-term, disturbance made Eurasian teal *Anas crecca* move away temporarily from observation blinds without leaving the waterbody. After disturbance, wildfowl fed more, i.e. disturbance disrupted their preferred resting activities. No such adverse disturbance impacts were found in either the medium or long term (Guillemain *et al.*, 2007).

19.63. Seven species of wintering dabbling ducks *Anas* in North America (including two species that occur in England and two New World counterparts of UK species) were subjected to disturbance from five different types of terrestrial human activity (Pease *et al.*, 2005). Most species were disturbed by all treatments, although responses varied with disturbance type, species and distance from disturbances. People walking and biking disturbed ducks more than did vehicles. Northern pintail *Anas acuta* was least sensitive to disturbance, whereas American wigeon *A. americana*, green-winged teal *A. carolinensis* and gadwall *A. strepera* were most sensitive. Ducks were more likely to flush when closer to sources of disturbance (Pease *et al.*, 2005).

19.64. Monthly counts of key UK waterbodies are conducted through the Wetland Bird Survey and reveal a fairly low incidence of disturbance events, which were defined so as to include birds of prey and environmental changes as well as human activities (Robinson and Pollitt, 2002). Two-thirds of fieldworkers observed no disturbance, a quarter noted moderate disturbance, 5% perceived high levels of disturbance and just 1% very high. Disturbance was less frequently recorded at still freshwater sites than at linear waterways, freshwater marshes or coastal and estuarine sites. One-quarter of perceived disturbance events had an anthropogenic cause. At inland waterbodies, waterborne activities were responsible for more disturbance events than landborne activities, although the latter were more numerous overall. Waterbirds appeared to show greater habituation to the more common human activities (e.g. walking) than to infrequent stimuli, such as boats and shooting (Robinson and Pollitt, 2002).

19.65. At the Cotswold Water Park models have been developed to explore the response to different types of disturbance, in relation to the distribution of aquatic macrophytes and other habitat variables, by waterfowl (O'Connell et al., 2007). Tufted ducks *Aythya fuligula* were found to be sensitive to human activities that were relatively infrequent and where the profile of a human was visible (e.g. walkers or dog walkers) and appeared to become habituated to high levels of vehicle activity. By contrast pochards *Aythya farina* were sensitive to all types of disturbance, including vehicular activity. Tufted duck did not avoid areas with lots of boating activity, but the preference for higher quality patches was stronger where these types of disturbance occurred.

19.66. Additional material published since the original guidance includes the waterbirds and wetland recreation handbook (Kirby et al., 2004), which provides a review of recreation impacts and a chapter on management recommendations.

Coastal Habitats

Colonial breeding seabirds and coastal breeding birds

19.67. Studies of two colonial seabirds nesting on a Scottish seacliff suggested that visitor numbers negatively affect breeding success. For black-legged kittiwake *Rissa tridactyla*, increasing overall visitor numbers by 8.5% resulted in a 22% decline in nesting success to 29.4%, while halving the visitor levels led to an increase in nesting success to 95.6%. With common guillemots *Uria aalge*, the same increase in visitor numbers resulted in a 13% decline in nesting success to 66.2%, while halving visitor levels increased nesting success to 87.2% (Beale and Monaghan, 2004b;Beale and Monaghan, 2005).

19.68. The key dynamic in both cases appears to be visitor party size. Human disturbance leads to reduced nesting success in common guillemots, albeit not as a simple direct consequence (i.e. nest failure rate is not related to visitor rate, and visitors do not flush birds directly from their nests) but due to indirect physiological costs (Beale and Monaghan, 2004b;Beale and Monaghan, 2004a;Beale and Monaghan, 2005). Increased heart rates as a result of disturbance led to increased breeding failure in black-legged kittiwakes (Beale, 2007).

19.69. Beale & Monaghan’s work suggests that fixed set-back distances and buffer zones may not be appropriate conservation measures at sites where the number of visitors varies spatially and temporally, as is generally the case. Instead, there is a need to ensure that larger parties of visitors are kept further away from the cliff or that set-back distances are determined for the largest party likely to visit the site. This can be achieved by moving viewpoints further away from nesting birds in line with visitor number increases. For a 10% increase in visitor numbers, the necessary increase in viewpoint distances to keep disturbance impacts static would be 1.3 m for common guillemots and 3.9 m for black-legged kittiwakes (Beale and Monaghan, 2004b).

19.70. Common Eider *Somateria mollissima* colonies are often subject to recreational visits, and the resulting disturbance is correlated with breeding failure (Bolduc and Guillemette, 2003). The timing of visits is more important than the frequency, with visits early in the incubation period significantly more likely to cause failure than visits later in that period. The majority of nest failures occur after a single visit. Failure rates are exacerbated in areas with high densities of nesting gulls *Larus* sp. (Bolduc and Guillemette, 2003).

19.71. While not specifically related to visitor access, disturbance by researchers of a colonially breeding seabird, Leach's Storm-petrel *Oceanodroma leucorhoa*, on both a weekly and daily basis during incubation reduced hatching success by 50% or more, and also reduced nest-site fidelity in subsequent years (Blackmer *et al.*, 2004).

19.72. In Portugal low breeding success of little terns *Sternula albifrons* has previously been shown to be associated with human activities (Calado, 1996). More recent work has shown that little terns have shifted away from nesting on sandy beaches and instead they are using man-made Salinas, a shift thought to be linked to human disturbance and habitat loss (Catry *et al.*, 2004). Detailed nest monitoring in Portugal has evaluated the influence of human disturbance on breeding success of little terns and the interaction with the seasonal variation in the birds' breeding biology (Medeirosa *et al.*, 2007). The percentage of nests producing hatched chicks varied in different years and habitats. The main causes of hatching failure also varied between years and habitats, but included predation, flooding and human activities. The presence/absence of protective measures (warning signs and wardening) was the most important predictor of nesting success, with birds being up to 34 times more likely to succeed when such measures were in place.

Shore-nesting waders

19.73. Studies have shown that human disturbance to beach-nesting birds can lead to trampling of eggs and chicks (Ruhlen *et al.*, 2003), greater thermal stress to eggs (Weston and Elgar, 2005), greater predation rate of chicks and eggs (Bolduc and Guillemette, 2003) and reduced foraging times (Yasue and Dearden, 2006).

19.74. Trampling of eggs and chicks seems to be more frequent on beaches than other habitats (Ruhlen et al., 2003;Woodfield and Langston, 2004a;Weston and Elgar, 2005). This may be because, particularly on a beach with the sea on one side, it is generally impractical to limit people to footpaths and the narrow linear habitat offers little physical space for segregation of birds and people (Woodfield and Langston, 2004a).

19.75. On the Norfolk coast, territory choice in ringed plovers *Charadrius hiaticula* and Eurasian oystercatchers *Haematopus ostralegus* was found to involve a trade-off between habitat quality (e.g. beach composition and width) and visitor numbers. Modelling suggested that a doubling of visitor numbers across the whole Norfolk coast would result in a 10% decline in the number of territories of both species, the first evidence of such an effect at a regional (rather than site) scale (Tratalos *et al.*, 2005).

19.76. Work by Liley (1999; for which see paras 12.2.19 - 21 of the original guidance) focused on a 9-km-long section of Norfolk coastline and found that ringed plovers avoided areas of high human disturbance and additionally suffered breeding failure through accidental trampling. Development of a model enabled prediction of the population consequences of hypothetical disturbance levels. If nest loss from human activity were prevented, for example by fencing nests, the plover population was predicted to rise by 8%. A complete absence of human disturbance would cause a population increase of 85%. However, if visitor numbers were to double, the population was predicted to decrease by 23% (Liley and Sutherland, 2007). Wide beaches support higher densities of breeding ringed plovers than narrow beaches and therefore locating access points away from the widest sections of beach is likely to result in the largest possible population per length of coastline (Liley and Sutherland, 2007).

19.77. Additional site-based research on the Norfolk coast has looked at the impact of visitor numbers on ringed plovers in relation to climate change (Coombs, 2007). The thesis is that warming temperatures will cause an increase in visitor numbers to the coast. At Holkham beach, current visitor levels already significantly reduce available habitat suitable for breeding ringed plover. Moreover, it is predicted that the increase in coastal visitor numbers that is a likely consequence of climate change will lead to further areas of habitat becoming unsuitable by 2080. The extent of suitable non-vegetated habitats may decrease by up to 73%, foredunes by 51% and yellow dunes by 55%. Parallel work at Cley beach nearby demonstrates that plover territories are currently restricted to the back of the beach where few visitors walk and that a further increase in visitor levels will not adversely affect the suitability of the habitat for the plovers (Coombs, 2007). The beach at this location (west of the coastguard café) is now no longer profiled as it used to be and subsequently is changing in form (S. Rees *pers. comm.*). This may affect the patterns of use by people and birds.

19.78. As a result of her work, Coombs recommended a series of measures to minimise biodiversity impact. These included restricting access to a single entrance point, creating defined paths through habitats to limit wandering, and restrictions on access to particularly sensitive areas (Coombes, 2007).

19.79. For the congeneric Malaysian plover *Charadrius peronii*, results were similar. The likelihood of hatching chicks and fledging young on Thai beaches was higher in territories with lower levels of human disturbance (Yasue and Dearden, 2006). However, work on this species suggests a general rule that site-specific variables such as the predation and thermal environment should be factored in when determining the susceptibility of birds to breeding disturbance. Plovers returned to the nest more rapidly following disturbance if the eggs were recently laid and the ambient temperatures higher. However, contra expectations, pairs that returned to their nest more quickly had lower hatching success, perhaps because birds that spend more time distracting humans through displays may do likewise for natural predators. Short nest return times cannot thus be assumed to indicate low fitness costs of disturbance. An improved understanding of breeding wader trade-offs to disturbance by human 'predators' may help site managers identify the location, times or populations where human disturbance may have significant effect on survival or productivity (Yasué and Dearden, 2006).

19.80. Human disturbance reduced Eurasian oystercatcher fledgling success by reducing foraging time and allocation of prey to chicks (Verhulst *et al.*, 2001). There are conflicting studies relating to disturbance to the closely related American Oystercatcher *Haematopus palliatus*. In one study, disturbance by humans on foot had very little effect, accounting for just 4% of events when adults left the nest (McGowan and Simons, 2006). In another study, however, human approaches on foot within ≤137 m (but not at greater distances) reduced the frequency of reproductive behaviours. The 8% of nesting attempts that failed because of human activity (handling the eggs and chronic disturbance) were located in areas of higher visitor presence (Sabine III *et al.*, 2008). The authors recommended that conservation managers: minimise pedestrian activity near nests (≤137 m) during incubation; increase set-back distances (to >137 m) during brood rearing; and consider closing beaches in high traffic areas (Sabine III *et al.*, 2008).

19.81. Most bird–disturbance research has focused on adult birds, but young birds (chicks and fledglings) may also be vulnerable to disturbance (in addition to suffering direct mortality from, e.g., trampling). Surveys of a globally threatened shorebird in Australia (hooded plover) revealed that disturbance caused energetic stress to chicks as higher disturbance levels resulted in reduced foraging time or movement to forage on sub-optimal but less disturbed areas. However, there was no evidence to suggest that human disturbance compromised overall brooding levels as a result of thermal stress induced by humans causing parents to cease brooding. Nor was there any evidence that human disturbance compromised adult defence of broods (Weston and Elgar, 2005).

Wintering Coastal birds

19.82. Disturbance from shore-based humans can adversely impact waterbirds in coastal bays etc, despite the protection offered by the different medium (Liley et al., 2006e). Numbers of black-necked grebes *Podiceps nigricollis* in a coastal bay in Dorset correlated negatively with numbers of people on the beach, with disturbance prompting birds to move to a nearby bay, where the feeding area is not as close to the beach so the impact of beach-based disturbance is lower. In this instance, the net effect of disturbance appears to be redistribution rather than population decline (Liley et al., 2006e).

Estuary shorebirds and geese

19.83. Shorebirds are often considered highly susceptible to disturbance because of their very obvious flight responses to humans and because they use areas that are generally subject to high levels of human recreational use. Many species may appear to avoid human presence (e.g. Ravenscroft et al., 2008) but this may not reduce the number of animals supported in an area. Assessing the influence of disturbance on the relationship between animal distribution and resource distribution provides a means of assessing whether numbers are constrained by disturbance (Gill *et al.*, 2001b). A variety of studies have examined the impacts of disturbance on the behaviour of estuary waders in particular. Some studies have sought to extrapolate findings to make inferences about population effects. Shorebird survival on non-breeding grounds is a factor in population limitation.

19.84. In general, disturbance from people walking along footpaths appears to have an adverse impact on the distribution of estuary birds, with numbers of four species (brent goose *Branta bernicla*, common shelduck *Tadorna tadorna*, dunlin and common redshank *Tringa totanus*) decreasing with increased proximity to a footpath access point on weekends, when use was likely to have been greatest (Burton *et al.*, 2002). Similarly, recreational use (particularly dogs running off the leash) of shorebird foraging areas reduces foraging time of sanderlings *Calidris alba*, according to a study in the United States (Thomas *et al.*, 2003b). Walkers were the most common potential disturbance event recorded in a study on two Suffolk estuaries (Ravenscroft et al., 2008).

19.85. In contrast, another study on the Suffolk estuaries, that looked at the effects of disturbance on wintering black-tailed godwits *Limosa limosa* found that the presence of footpaths had no effect of the numbers of birds supported by adjacent intertidal areas once bivalve food supply had been taken into account (Gill *et al.*, 2001a). However, caution was suggested in extrapolating these findings to other species or other life-cycle stages, particularly because fieldwork was only conducted on weekdays, when recreational disturbance can be assumed to have been lower (Woodfield and Langston, 2004a).

19.86. Three studies have examined the impact of disturbance on Eurasian oystercatchers wintering on European estuaries (West et al., 2002;Coleman et al., 2003;Goss-Custard et al., 2006). Research at a French estuary shows the important of factoring in environmental variables to assessments of the fitness impacts of disturbance. Modelling shows that oystercatchers can be disturbed up to 1.0–1.5 times per hour before their fitness is reduced in winters with good feeding conditions but only up to 0.2–0.5 times per hour when feeding conditions are poor (Goss-Custard *et al.*, 2006).

19.87. Experimental disturbance of wintering oystercatchers on an estuary in Devon altered behaviour and reduced foraging success, but without causing them to fly (Coleman *et al.*, 2003). At the same site, another study used a behaviour-based model was used to predict the impact of human disturbance on the species (West *et al.*, 2002). The model predicted that numerous small disturbances would be more damaging (in terms of bird survival and thus population size) than fewer, larger disturbances. When the time and energy costs arising from disturbance were included, disturbance could be more damaging than permanent habitat loss. However, preventing disturbance during late winter, when feeding conditions were harder and this migratory bird's energetic demands higher, practically eliminated its predicted population consequences (West *et al.*, 2002).

19.88. Modelling found that eight shorebird species on the Wash estuary (West *et al.*, 2007) might be more resilient to disturbance than the Eurasian oystercatchers modelled on the Exe estuary (Goss-Custard *et al.*, 2006), although other factors such as energy needs were not factored into the experiment. According to the model, the survival of all species studied (black-tailed godwit, bar-tailed godwit *Limosa lapponica*, Eurasian curlew *Numenius arquata*, Eurasian oystercatcher, red knot *Calidris canutus*, redshank, dunlin *Calidris alba* and ringed plover) remained high as long as there were fewer than 20 disturbances per hour. Although actual disturbance rates on the Wash were not measured during this study it is unlikely that present-day rates of disturbance represent a threat to the survival of the bird species modeled (West et al., 2007).

19.89. Waders with high roost-site fidelity and minimal interchange between roosts have been thought likely to be at risk from human disturbance (Rehfisch *et al.*, 2003). However, a recent study produced no evidence that terrestrial human activity impacts on roosting waders, e.g. by preventing roosts from forming or causing roost-sites to move. Roosting waders studied in the coastal United States included two species with wintering populations in the UK (ruddy turnstone *Arenaria interpres* and red knot) and one species with a European counterpart (American oystercatcher): terrestrial disturbance did not appear to be a factor for any species (Peters and Otis, 2007).

19.90. Human disturbance of thousands of migrating shorebirds at Delaware Bay in the United States has declined sharply since a variety of management actions were introduced in the 1990s. Signs were placed on shorebird foraging beaches, dog-walkers were encouraged to keep dogs on the lead, spatial restrictions on access were introduced, and viewing platforms constructed. These were complemented by enforcement activities, such as patrols of key beaches and the issuance of summonses for infractions (Burger *et al.*, 2004).

19.91. Following modeling of wintering Eurasian oystercatchers on a Devon estuary, researchers recommended that to almost entirely eliminate the predicted population consequences of disturbance, site managers should prevent disturbance to the birds during late winter, when feeding conditions were harder and this migratory bird's energetic demands higher (West *et al.*, 2002). The model used has been designed to be easily applied to other scenarios, species, locations and issues (West *et al.*, 2002).

19.92. The presence of hand harvesters (both professional shellfishers and recreational baitworm diggers) on a Spanish tidal flat had a significant effect on the foraging activity of migrating Eurasian curlews. To reduce this, researchers recommended that intertidal coastal managers limit the harvesting load to <0.56 persons per 10 ha at least during autumn migration (Navedo and Masero, 2007).

19.93. Recreational use of shorebird foraging areas (particularly by dogs) reduces the foraging time of sanderlings (Thomas *et al.*, 2003b). Researchers recommended that managers introduce a setback distance of at least 30 m and strictly enforce dog-leash laws.

Implications of research

Species particularly susceptible or unsusceptible to human disturbance

19.94. Based on an assessment of research on the behavioural, demographic and population impacts of disturbance, some insights from recent research can be gained into relative susceptibility of different species. While aware that response to disturbance is, in part, species-specific, this chapter may guide the application of single-species studies to other taxa.

19.95. It is also worth recalling that the more fragile a species' conservation status is (e.g. due to small, localised or declining populations), the greater the potential population effect of any human disturbance. As in the original guidance it is possible to highlight species that, because they have localised distributions, are rare, or occur in particular aggregations, may be vulnerable to localised impacts such as disturbance. This list, known as "Category A" has been developed by Natural England staff and is included in Appendix I, along with details of how the list has been constructed.

19.96. Terrestrial nesters are considered particularly vulnerable to human disturbance, particularly in open areas such as moors, heaths and coasts (Woodfield and Langston, 2004a) as they are more likely to leave the nest as a result of perceived increased predation risk (Lord *et al.*, 2001). Settlement patterns of ground-nesting birds may be restricted by high levels of human disturbance (Liley, 1999;Liley and Sutherland, 2007), and birds' productivity may be reduced as a result of human-caused nest inattentiveness increasing the susceptibility of eggs to thermal stress or predation (Bolduc and Guillemette, 2003;Blackmer et al., 2004;Langston et al., 2007c).

19.97. Most species of wader nest on the ground and are thus susceptible to disturbance. Ringed plovers nesting in Norfolk avoided areas of human disturbance and additionally suffered nest failure (i.e. direct mortality of eggs or chicks) due to accidental human trampling (Liley, 1999;Liley and Sutherland, 2007). There is potential for disturbance impacts on ground nesting birds, at least, to be felt at the population level, for example as with stone-curlew (Taylor *et al.*, 2007) and ringed plover (Liley, 1999;Liley and Sutherland, 2007). Other susceptible ground-nesting waders include Eurasian oystercatcher (Tratalos *et al.*, 2005), dunlin and golden plover (Pearce-Higgins *et al.*, 2007). Some heathland specialists also fall into this category, such as Eurasian nightjar (Langston et al., 2007c) and woodlark (Mallord *et al.*, 2007b).

19.98. Colonial breeders are also of concern, as a single disturbance event has the potential to affect the breeding success of large numbers of breeding birds, a risk that may be exacerbated by the strong competition that may exist between birds nesting in such close proximity (Beale and Monaghan, 2004b). Examples of colonial species studied include common eider (Bolduc and Guillemette, 2003), common guillemot and black-legged kittiwake (Beale and Monaghan, 2004b;Beale and Monaghan, 2005;Beale, 2007). Large colonies may be able to subsume such disturbance more effectively than small colonies. There are thus strong grounds for management actions such as restricting human access to breeding colonies and establishing viewpoints at suitable set-back distances (Woodfield and Langston, 2004a;Beale, 2007).

19.99. Wildfowl and waders wintering on estuaries may also be particularly susceptible to disturbance, particularly where heavily used footpaths pass close to foraging areas or roost-sites (Burton et al., 2002;Goss-Custard et al., 2006). Susceptibility may be increased at time of high energy needs, for example prior to migration, when the need for food may outweigh the risk of predation with potential physiological and fitness costs (Stillman and Goss-Custard, 2002). However, waders may not be affected equally: black-tailed godwits appeared not to be susceptible to disturbance, at least at weekday levels (Gill *et al.*, 2001a).

19.100. It is conceivable that wildfowl are rather less susceptible (or rather more resilient) to disturbance. Seven species of *Anas* dabbling ducks in North America (including two species that occur in England and two New World counterparts of UK species) were disturbed by five different disturbance treatments, although responses varied with disturbance type, species and distance from disturbances (Pease *et al.*, 2005). However, whilst disturbance to Eurasian teal prompted temporary movements away from the source and diverted birds from resting to foraging, it apparently had no medium- or long-term effects (Guillemain *et al.*, 2007). It should be noted that neither of these studies assessed the disturbance impacts of hunting, which poses a direct mortality risk.

Human presence can indirectly increase natural predation levels

19.101. In many areas, corvids are an important nest predator. More frequent presence of humans may increase predation rate on clutches and small chicks by attracting more corvids to feed on discarded food scraps (Storch and Leidenberger, 2003;Langston et al., 2007c). In a study in North America, two species of corvid occurred at higher densities, had greater breeding success near human settlement and recreation sites, and also accounted for a third of predation events documented on artificial nests, with predation rates being higher near areas of human activity (Marzluff and Neatherlin, 2006). Disturbance by rock-climbers appears to exacerbate predatory success of ravens on peregrines (Brambilla *et al.*, 2004).

19.102. A study in southern England assessing the impact of predation on artificial woodlark nests found a positive correlation between human visitor levels and corvid numbers, and between corvid numbers and nest predation, suggesting that human activity increases the density of avian predators (Taylor, 2002). It would be useful to determine whether these findings with regards artificial nests also apply to real nests (Woodfield and Langston, 2004a). Common eider breeding failure rates due to visitor disturbance are particularly high in areas with high densities of nesting gulls *Larus* (Bolduc and Guillemette, 2003).

19.103. However, the correlation between human disturbance, predator density and nest predation levels is not always so clear. Nest mortality of white-faced plovers *Charadrius marginatus* in South Africa, mostly by natural mammalian and corvid predators, was significantly lower at the site experiencing high recreational activity (Baudains and Lloyd, 2007).

Dog-walking presents a particular problem during the breeding season

19.104. Research increasingly suggests that dog-walking presents a particular problem for bird conservation managers. Dogs off-leads can cover much more ground than people and do not necessarily remain on paths (e.g. Liley et al., 2006g). They can sniff out ground-nesting birds in dense cover that would otherwise be hidden.

19.105. Birds tend to flush more readily in response to dogs than people (Lord et al., 2001;Taylor et al., 2007). When flushed by a dog, stone-curlews (and potentially other bird species) tend to stay away from the nest for a longer duration than if they are flushed by humans (Taylor *et al.*, 2007). Dogs directly predate and trample eggs and chicks (Murison, 2002). As most nightjar breeding failures happen during incubation (Murison, 2002;Woodfield and Langston, 2004b), a single dog running off-path into the heather could disturb large areas of nightjar breeding habitat. Dogs can also result in increased predator vigilance, even when they are not visible to the bird but instead are detected aurally. Vigilance in common coots *Fulica atra* increased significantly in response to hearing barking dogs, an increase comparable to that induced by the presence of a predator (Randler, 2006). For Dartford warblers, dog-walkers accounted for 60–72% of all disturbance events, with dogs off-lead and off-path the greatest threat to breeding productivity (Murison, 2007;Murison et al., 2007).

Habituation

19.106. If habituation occurs then the impacts of disturbance will be reduced (Sutherland, 2007). Our understanding of habituation is still limited and further work is warranted in this area.

19.107. There are however studies which have shown habituation to occur. For any given level of disturbance, incubating white-faced plovers breeding on South Africa shorelines were more attentive at the site with higher disturbance levels. They achieved this through habituation, allowing a closer human approach before leaving the nest, and returning to the nest faster after a disturbance event (Baudains and Lloyd, 2007).

Notes of caution when assessing management options

19.108. The impacts of disturbance do not occur in isolation, and may be reduced or exacerbated by other factors (e.g. weather conditions, nest cover, changes in prey availability); such interrelationships would be worthy of further research (Woodfield and Langston, 2004a).

19.109. Moreover, behavioural responses may not necessarily reflect the potential fitness costs of human disturbance (Gill, 2007) and the consequences of human disturbance may also vary according to the stage in the species' life cycle (Woodfield and Langston 2004). Shorebirds in Canada responded more to a disturbance when the foraging costs are lower (e.g. during the morning or when little prey is available). The severity of behavioural response to a disturbance depends both on the perception of threat severity (Frid and Dill, 2002;Cassini et al., 2004) and the costs of the response (Stillman and Goss-Custard, 2002;West et al., 2002;Beale and Monaghan, 2004b;Beale and

Monaghan, 2004a). Birds react more to disturbance when the threat is greater (Frid and Dill, 2002;Thomas et al., 2003a) and react less when energetically stressed (e.g. prior to spring migration mean that birds spend longer feeding and so have less spare time in which to compensate for disturbance) and when the fitness cost of responding was greater (Stillman and Goss-Custard, 2002;Beale and Monaghan, 2004a).

19.110. Conversely, experiments on ruddy turnstones, a coastal wader, have shown that behavioural responsiveness is positively related to condition. Birds whose condition had been enhanced by feeding were more responsive to human disturbance, flushing at greater distances and flying further. It follows that individuals showing little or no response to disturbance may in fact be those with most to lose from changing their behaviour (Beale and Monaghan, 2004a). Consequently, a larger behavioural response cannot be assumed to mean that a species is more vulnerable to disturbance—because the opposite may be true. To better understand the impact of disturbance, studies should measure both behavioural responses and the ease with which animals are meeting their requirements.

19.111. These findings have implications for conservation site managers as there are risks that our current management of the impact of human disturbance may be based on inaccurate assessments of vulnerability (Beale and Monaghan, 2004a). It may be worth identifying management options to mitigate against perceptions of high threat levels, but less so when birds fly off because doing so incurs few costs (e.g. good feeding areas nearby). Birds that are readily flushed by humans may not be the ones suffering the most (Yasue, 2006). Previous studies have tended to assign conservation priority to the level of disturbance noted, neglecting the cost side of the equation; more research on costs may contribute to a better assessment of the true sensitivity of a species to disturbance.

19.112. Given that site management measures need to be deployed selectively to be most effective (Langston et al., 2007a), conservation effort should be directed towards species which need to spend a high proportion of their time feeding, but still have a large response to disturbance (Stillman and Goss-Custard, 2002)—particularly if they are already under pressure, e.g. due to small populations or restricted distribution. In the absence of population modelling data, conservation managers might strive to minimise the impacts of disturbance on species' fitness rather than on the severity of behavioural response. Yasué suggests focusing on the costs of disturbance on two important parameters—predation risk and foraging rates—as a feasible alternative to long-term studies that follow individual birds throughout different stages of their life cycle (Yasue, 2006).

19.113. Fortunately, behavioural responses to disturbance can be linked to population consequence by using individual-based models, consisting of fitness-maximising individuals (Stillman *et al.*, 2007). These models have been used to predict the effect of disturbance (albeit mainly on sources other than recreational access) on populations of wildfowl and shorebirds at several European sites (Stillman and Goss-Custard, 2002). It is thought that models can be developed relatively quickly, but this still equates to 1–2 years including data collection (Stillman *et al.*, 2007). Models can be used to assess the effect of present-day disturbance on mortality rate, compare the relative effects of alternative future disturbance scenarios and predict the best ways of managing disturbance (Stillman *et al.*, 2007).

19.114. An individuals-based model can be used to set maximum disturbance rates for each species by predicting how disturbance rates influence shorebird survival (West *et al.*, 2007). These can be used to establish critical disturbance thresholds, i.e. to determine the frequency with which waders can be disturbed before they die of starvation. Modelling shows that Eurasian oystercatchers on a French estuary can be disturbed up to 1.0–1.5 times/h before their fitness is reduced in winters with good feeding conditions, i.e. abundant cockles *Cerastoderma edule* and mild weather, but only up to 0.2–0.5 times/h when feeding conditions are poor, i.e. scarce cockles and severe winter weather (Goss-Custard *et al.*, 2006).

Thresholds

19.115. Recent studies indicate that there is a threshold level of disturbance at which upland-breeding waders can no longer tolerate disturbance, that this threshold differs between species, and that management measures can be used to resolve the situation in heavily disturbed areas (Langston et al., 2007a). High levels of disturbance can impact on habitat usage by golden plover and dunlin, but only where visitor pressure is very high (more than 30 visitors per weekend day) and there is a network of poor-quality sites. However, resurfacing work on the Pennine Way at Snake Summit appears to have successfully resolved the conflict between human visitor pressure and upland wader conservation interest (at least in terms of golden plover and dunlin; it remains to be seen whether the same applies to warier waders such as common redshank and Eurasian curlew. Thus, provision of a waymarked, well-surfaced route can enable the access for large (and even significantly increased) numbers of visitors without impacting upon wader breeding performance. This approach works even where there are few access restrictions, and thus can be applied to designated open access land; this approach would seem particularly appropriate in extensive areas of habitat where footpaths have the additional benefit of facilitating visitor access (Pearce-Higgins *et al.*, 2007).

19.116. Managers lack conservation guidelines as to whether to best meet conservation objectives by spreading visitors thinly throughout a reserve or by aggregating them in a small area. Modelling work at a seabird colony shows that relationships between disturbance impact and disturbance pressure (the ‘dose-response curve’) can be used to address this issue, which, in turn, suggests that optimal management can shift from one management option to the other if visitor numbers pass a certain threshold (Beale, 2007). Optimal visitor management depends on the sensitivity of the species, the shape of the dose-response curve and the levels of visitor disturbance at the site. While visitor management realities mean that it is easier to aggregate visitors than spread them thinly, for a site where visitor pressure is fairly low and the birds being visited are thought not to be particularly susceptible to disturbance, it is likely that spreading visitors thinly is most likely to be optimal (Beale, 2007).

19.117. At sites with high disturbance pressures, the optimum management option is to aggregate visitors in as small an area as possible. At sites with low disturbance pressure, a better approach is to obtain an even distribution of visitors. The tipping point appears to be disturbance pressure of 0.62 people minutes/h/m. For colonial seabirds (and probably other colonial breeding birds), unless either the species concerned is very strongly sensitive to disturbance or site visitor pressure is very high, spreading visitors thinly across the site is likely to be the most generally preferable management strategy (Beale, 2007). These findings may well be useful for management at (the few) common guillemot breeding colonies in England. It may also be applicable to other colonial seabird species.

19.118. It would be highly convenient to be able to identify particular levels of disturbance at which disturbance impacts may occur and to manage access accordingly (i.e. maintaining access levels below the level identified as having an impact). Such levels will always be difficult to identify and are likely to be dependent on a range of factors, including bird density, and in reality a continuum, rather than a clear cut-off point is always likely to be present.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

Methods for assessing these circumstances

The impacts of open access

19.119. Prior to CRoW, access to sites was often restricted to footpaths, but even such linear disturbance has a demonstrable effect on certain species (e.g. nightjars on heathlands and ringed plovers on beaches). Open access potentially widens the area of disturbance. Moreover, birds may find it more difficult to predict where access will occur, and cannot simply avoid areas near footpaths (as with, e.g. dunlin and golden plover).

19.120. Open access is likely to change visitor distribution across a site (as visitors are not restricted to paths) as well as overall numbers. It is important to take into account both elements: doubling visitor levels is thought likely to have a greater effect on woodlark populations when distributed evenly rather than in line with actual access patterns (Mallord et al., 2006;Mallord et al., 2007c). Aggregation of visitors in particular parts of a site is likely to result in locally increased disturbance impacts, but to the benefit of the rest of the site, which remains undisturbed (Pearce-Higgins *et al.*, 2007). Alternatively an even spread of visitors ensures birds across the whole area experience similar low exposure to people (Beale, 2007).

Original guidance: assumptions and assessment of key species and habitats

19.121. Viewed in the light of research published since 2001, the five assumptions offered to guide access management decisions in the original WAAG guidance (see paras 12.3.2 and 12.3.8) appear to remain broadly appropriate.

19.122. The list of species potentially affected by the introduction of a statutory right of access (as set out in the WAAG guidance, Appendices 6–7) also remains appropriate, with two exceptions: golden eagle (an exceptionally rare breeding species in England) is missing, and it should be noted that the globally threatened Aquatic warbler *Acrocephalus paludicola* occurs in England only as a rare passage migrant rather than as a breeding bird, as stated. Although coastal habitats (e.g. estuaries) were not covered in the original WAAG guidance, Appendix 7 already contains the key species in these habitats within the category ‘feeding and roosting wetland birds’.

19.123. The body of work on nightjars, woodlarks and Dartford warblers supports the recommendations in the original guidance (chapter 12.6.5.) for management measures or statutory restrictions/exclusions to be considered for heathlands with nationally or internationally important concentrations of nightjar, woodlark or Dartford warblers between February and September inclusive.

19.124. Exclusions have been given for black grouse, focusing on the lek sites where the birds congregate in the spring. Work in the European Alps has found reduced numbers of black grouse in areas where winter sports and outdoor activities take place (Patthey et al., 2008), but there is no clear evidence that increased human access will impact negatively on black grouse in the UK (Baines and Richardson, 2007) . Patthey et al advocate reserves where human access is banned or limited, while Baines & Richardson suggest (should high levels of access occur): restrictions on access within 200 m of wintering grounds where flocks congregate; extension of these areas to encompass enclosed ground with breeding black grouse; existing restrictions extended regarding keeping dogs on leads during the breeding season from the end of July until August; increased visibility of fence and overhead wire hazards within 200 m of access routes through key areas for fleeing birds; and provision and promote viewing facilities for birdwatchers at leks (Richardson and Baines, 2004;Baines and Richardson, 2007).

19.125. The original guidance on downland (chapter 12.7) lists stone-curlew and European quail *Coturnix coturnix* as being the key avian concerns in this habitat. Recent research on stone-curlew is covered in the chapter on *Heathland* above. No new information is available on quails.

19.126. The WAAG 2001 guidance (see paras 12.8.10 - 13) notes concerns related to vulnerable concentrations of roosting wetland birds, colonies of coastal nesting birds and raptor roosts.

19.127. We are not aware of any information relevant to bird–disturbance issues in bogs or reedbeds that has been published since 2001. We thus do not update the original guidance (see paras 12.8.17 - 18).

19.128. The concerns in the original guidance (see paras 12.8.19 - 12.8.20) regarding woodlands relate solely to roosting red kites and breeding colonies of grey heron and little egret. We are not aware of any information relevant to bird–disturbance issues on such species that has been published since 2001. We thus do not update the original guidance. It is unlikely that any of the three species listed would be molested by dogs, but even so we note the findings in an Australian woodland that dog-walking led to a 35% reduction in bird diversity and 41% reduction in abundance, both in areas where dog walking is common and where dogs are prohibited (Banks and Bryant, 2007).

19.129. The original Guidance (see paras 12.8.22 - 23) notes concerns about disturbance to nationally and internationally important bank-side aggregations of wetland birds. Such concerns are warranted, given that more than 200 sites in the UK are currently of international importance for one or more species of waterbirds, and more than 50 regularly hold at least 20,000 individuals (Collier *et al.*, 2005).

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20. MAMMALS

Summary

- Recent research on UK mammals contributes a few considerations in addition to those presented in the original guidance (chapter 13.6). Human recreational disturbance, particularly dog-walking, has been shown to affect red deer *Cervus elaphus* behaviour and may impose fitness costs that would warrant selective and site-specific management action. Disturbance has been shown to be a highly significant factor in Eurasian badger *Meles meles* sett-site selection and a factor in European otter *Lutra lutra* distribution. Site management is likely to be necessary to avoid disturbance to otter holts. Recent research stresses the benefits of cave-gates at sites heavily used by bats, a measure already commonly used. A precautionary minimum spacing between horizontal cave-gate bars is recommended to be 150 mm.

- Seals can show a strong behavioural response to disturbance and for some species (outside the UK), human disturbance has been a major factor in their decline. Studies from the UK show differences between sites in how seals respond to disturbance. Grey seals *Halichoerus grypus* are currently expanding in range and population size and disturbance is unlikely to be a problem, but for harbour seals *Phoca vitulina* disturbance may be an important issue and access around harbour seal colonies should be carefully controlled and monitored.

- _Evidence from studies of mammals outside the UK (Naylor 2006, Taylor and Knight 2003, Gander and Ingoid 1997, Papouchis et al 2001) does not suggest a consistent pattern in the levels of disturbance imposed by horse riding and mountain biking relative to pedestrian access. There is no evidence of higher rights activities causing direct mortality or influencing behaviour of UK mammals, although direct mortality of small mammals is certainly imaginable. It is possible that cycling and horse riding may have indirect effects on mammals (e.g. via trampling on vegetation, eroding soils.

Accessibility of Sites with Mammals

20.1. No new information.

General Vulnerability of Mammal Sites to Direct Impacts arising from Access

20.2. In 2005 lead partners involved in the UK BAP were asked to report on their species and habitats (Defra, 2006). The reporting included identifying current or emerging threats. Disturbance issues (including infrastructure) were identified as threats for seven mammal species, primarily bats (Table 6).

Table 6: BAP priority mammal species (from 2005) where disturbance or housing issues identified as a current or emerging threat. Data are from 2005 BAP reporting round. Coastal erosion and habitat loss / degradation from development are included in the table as these can be access related.

	Habitat loss / degradation as a result of housing infrastructure	*Human disturbance resulting in interference / displacement*
Water Vole	✓	
Barbastelle Bat	✓	✓
Dormouse	✓	
Bechstein`s Bat	✓	
Pipistrelle Bat	✓	✓
Greater Horseshoe Bat	✓	
Lesser Horseshoe Bat	✓	✓

Badgers

20.3. In a study in Italy, disturbance was the second most important factor affecting Eurasian badger *Meles meles* sett-site selection (Prigioni and Deflorian, 2005).

Red deer

20.4. There have been two recent studies of the impact of disturbance on red deer *Cervus elaphus* in the UK. One study focused on red deer stags that were used to seeing people on foot, spending two-thirds of each year in a well-frequented glen, and thus reasonably habituated to human presence (Sibbald *et al.*, 2001). Nevertheless, stags responded to increased recreational activity on weekends by staying 100 m further away from the path than on weekdays (when disturbance was lower). Stags also changed both habitat and habits on weekends. First, they spent more time in woodlands than open grassland; this could influence their energy consumption given that open grassland offers greater nutritional rewards. Stags did not appear to compensate for this lost foraging time by frequenting the grassland at night, when disturbance was nil. Second, stags covered more distance on weekends than during the week, thereby expending more energy on the same days when their calorific intake was presumably lower (Sibbald *et al.*, 2001).

20.5. Due to the extinction of their natural predators, red deer in the UK face predation only by humans. However, red deer are also increasingly exposed to disturbance from human recreation. Both types of disturbance may be perceived by the deer as a predation risk. Research on the impacts of disturbance on red deer in Scotland concluded that the species respond to disturbance from human recreational activities by increasing their level of vigilance, but that the nature of their response varies with the level of cover available. Deer were more vigilant in disturbed habitats than less-disturbed habitats and appeared to make a trade-off between vigilance and foraging (Jayakody *et al.*, 2008).

20.6. In the disturbed sites, there was a very clear effect of habitat on the mode of vigilance. In most habitats, the majority of vigilant animals were standing. In disturbed grassland, however, lying was the main posture whilst vigilant. In both disturbed grassland and heather, the percentage of vigilant animals that were moving was higher than in woodland or the less-disturbed habitats. Researchers suggest that red deer may lie down when keeping vigil in grasslands, because lying animals are less conspicuous and the low cover will still allow animals to scan their surroundings (Jayakody *et al.*, 2008).

20.7. In disturbed sites, the deer were more likely to be aggregated when vigilance levels were high. During the hunting season, the overall level of vigilance was higher than at any sites during the recreational season, and the majority of vigilant animals were moving. Researchers conclude that, although they respond to both types of disturbance by increasing vigilance, red deer perceive human recreation as a less acute threat than hunting. However, deer were found to respond more to dogs than people on foot, dogs causing increased levels of vigilance and aggregation of the deer, possibly because deer have evolved anti-predator defences against canids, having historically lived alongside wolves *Canis lupus* in the UK (Jayakody *et al.*, 2008).

Roe deer

20.8. A recent study determined flight initiation distances (FID) in response to human disturbance for roe deer *Capreolus capreolus* (and fallow deer *Dama dama*) in the Netherlands (de Boer *et al.*, 2004). Of all factors studied, hunting regime and habitat structure were most strongly related to flight distance, with FID higher in more sparse vegetation and with higher hunting activity. When downwind, both species deer flee at longer distances than when upwind or in calm conditions (de Boer *et al.*, 2004).

Otters

20.9. The original guidance (see paras 13.3.7 - 13) notes evidence that suggests that European otters *Lutra lutra* will tolerate a degree of disturbance. Two recent studies (Prenda et al., 2001;Robitaille and Laurence, 2002) do not directly contradict this supposition, but do suggest that the species is less likely to occur where greater human disturbance exists.

20.10. A study in Spain suggested that, in general, otters occurred in unpolluted habitats with high bankside vegetation cover, and low or very low levels of human disturbance (Prenda *et al.*, 2001). A pan-European study of otter distribution found that significantly higher human and road densities were detected in areas where otters are absent, which was thought to illustrate the pervasive impact of human presence on otter population fragmentation (Robitaille and Laurence, 2002).

Small mammals

20.11. The only relevant research published on small mammals since 2001 was a survey of the geographical distribution and habitat occurrence of Water Shrews *Neomys fodiens* in south-east England found no signs of habitat avoidance in response to human disturbance; water quality seemed to be a far bigger limiting factor (Greenwood *et al.*, 2002).

Bats

20.12. Bats make extensive use of caves and mines as nursery roosts, swarming sites and hibernacula. The original guidance comments that bats using caves are much more vulnerable where either general public or specialist users have access to the cave entrance. Indeed, persistent human disturbance is a major cause for the decline in populations of many cave-dwelling bats.

Cave-gating has been used to eliminate human disturbance, but has been feared to impede bat movement. However, relatively few studies have looked at either the short or long-term effects of gates on bat behaviour and population sizes. Two recent studies have considered the impact of such management activities on resident bats (Martin *et al.*, 2003) and compared the effect of different gate structures on bats (Pugh and Altringham, 2005).

20.13. Researchers in the US assessed the impact of adding internal gates on grey bats *Myotis grisescens* caves (Martin *et al.*, 2003). No caves were abandoned; indeed, grey bat numbers stayed level or increased in each cave. Moreover, no differences in timing of initiation of emergence were found between colonies in gated versus open-passage caves (Martin *et al.*, 2003).

20.14. Early cave-gate design often gave little regard to bats, leading to massive population declines in many nursery and hibernation sites (Pugh and Altringham, 2005). Free access to bats has become an increasingly important design feature. An assessment of the effect of different gate designs on bats suggested that those with 150 mm spacings had no significant effect on the behaviour of the bats (predominantly Natterer's bat *Myotis nattereri*). Gates with both 130 mm and 100 mm spacing caused a significant and substantial increase in the number of bats aborting their first and often subsequent attempts to enter the cave. The consequences to swarming behaviour and long-term use of the site by bats are unknown, but researchers suggest that, following the precautionary principle, the minimum spacing between horizontal bars in gates should be 150 mm (Pugh and Altringham, 2005).

Seals (addition to original guidance)

20.15. UK populations of both grey seal *Halichoerus grypus* and harbour seal *Phoca vitulina* (formerly known as common seal) are internationally important, accounting for 45% and 33% of their respective EU populations (Special Committee on Seals (SCOS) and Sea Mammal Research Unit, 2007).

20.16. There is a wide range of studies addressing disturbance to pinnipeds, but relatively little from the UK (Table 7). The studies show a range of behavioural responses, with most studies focusing on hauled-out seals fleeing a source of disturbance. For some species such as the Mediterranean and Hawaiian monk seals, human disturbance is clearly a key factor in their population decline.

Table 7: Examples of disturbance impacts to seals.

Impact of disturbance	Species	Location	Reference	Notes
Behavioural responses				
Aggression towards people	South American fur seal	Uruguay	Cassini ((2001); Cassini *et al.*(2004)	Colony visited by tourists
Hauled out seals fleeing and entering sea	South American fur seal, ringed seal, harbour seal, grey seal, Mediterranean monk seal	Uruguay, Greenland, Alaska, Wales, Mediterranean	Cassini ((2001); Cassini *et al.*(2004); Born *et al.* (1999); Lewis and Matthews (2000); Westcott and Stringell (2003); Johnson and Lavigne (1999); Brown & Prior (1998)	Response documented to people on foot, in kayaks, boats and on aeroplanes
Disturbance of dominant male allowing young bulls into harem	Grey seal	Norfolk	Skeate and Perrow (2008)	
Avoidance of areas of high disturbance by nursing mothers	Grey seal	Lincolnshire	Lidgard (1996)	
Abandonment of colonies / local extinction	South American fur seal, Mediterranean monk seal	Peru, Mediterranean	Stevens and Boness (2003); (2003); Johnson and Lavigne (1999)	Peru study showed colonies abandoned were mainland ones with higher levels of disturbance
Increased vigilance	Southern elephant seal, grey seal	Sub-antarctic, Wales	Engelhard *et al.(Engelhard et al., 2002a)*; Westcott and Stringell (Westcott and Stringell, 2003)	
Separation of mothers from pups	Mediterranean monk seal, Harbour Seal	Mediterranean, Shetland	Ronald and Yeroulanos (1984, quoted in Johnson & Lavigne 1999), Brown and Prior (1998)	
Population impact of disturbance				
Population decrease	Hawaiian monk seal, Mediterranean monk seal	Hawaii, Mediterranean	Gerrodette and Gilmartin (1990); (2003); Johnson and Lavigne (1999)	Hawaiian study found a change in demographic parameters following access management
No effect of human disturbance				
No impact on population size	Southern elephant seal	Southern oceans, South Georgia, southern Argentina etc	McMahon (2005)	Many sites remote and with comparatively low levels of disturbance
No difference in pup weights between colonies subject to different levels of disturbance	Southern elephant seal	Sub-antarctic	Engelhard *et al.* (2001)	Series of studies comparing sites with high and low levels of human activity
No difference in blood chemistry between colonies subject to different levels of disturbance	Southern elephant seal	Sub-antarctic	Engelhard *et al.* (2002b)	
No difference in lactation between colonies subject to different levels of disturbance	Southern elephant seal	Sub-antarctic	Engelhard *et al.* (2002a)	

20.17. Large groups of people, intrusive behaviour (running, waving, shouting) and close approach are more likely to invoke a behavioural response (Brown and Prior, 1998;Cassini, 2001;Cassini et al., 2004). The distances at which seals respond to people varies widely, Cassini *et al.* (2004) document approaches by people to within 10m, whereas Lewis and Matthews (2000) give an average approach distance for pedestrians of 124m before the seals entered the water. Lewis and Matthews found no significant differences in the average approach distance when comparing pedestrians, kayakers and people on boats. Brown and Prior (1998) found that visitors with cameras or camcorders approached seals more closely than those without, and that the closer approaches resulted in stronger reactions (seals more likely to flee). Only a small proportion of flushes (10%) occurred at distances in excess of 100m, and 65% occurred at distances under 60m.

20.18. Behavioural responses to disturbance are likely to vary between species, sites and depending on season and activity of the seals. Comparisons between individual seals and between different beaches in north Wales showed clear differences in how the seals responded (Westcott and Stringell, 2003).

20.19. There is little information on the impacts of disturbance at a population scale. Disturbance has been clearly linked to population decline in the Mediterranean monk seal (see Johnson and Lavigne, 1999 for a review) and Hawaiian Monk Seal (Gerrodette and Gilmartin, 1990). In the study by Gerrodette *et al,* recreational beach activities caused seals to alter their pupping and hauling patterns. Survival of pups in suboptimal habitats was low, leading to gradual population declines. During the last decade at certain locations, human disturbance on beaches has decreased and traditional pupping and hauling sites have been reestablished. There have been dramatic changes in the age and sex composition of the population, suggesting that apparently small behavioral changes can have large demographic consequences. Population analyses on southern elephant seals has suggested that human disturbance has no affect on population size (McMahon et al., 2005).

20.20. The number of studies from the UK is limited. Brown and Prior (1998) studied Harbour Seals on Mousa SAC in the Shetlands. The effect of 168 groups of visitors on the behaviour of hauled out seals was recorded: a behavioural response to disturbance was recorded for 61% of groups and 40% of all groups caused seals to take flight and enter the water. For Brown and Prior (1998) the primary concern was for mothers and pups during June and July. Human interference caused mothers to abandon pups, or to abandon ideal nursery sites. Prolonged disturbance caused seals to abandon haul-out sites. They suggest that some form of visitor control is necessary to reduce disturbance.

20.21. Research on grey seals at Donna Nook in Lincolnshire (Lidgard, 1996, in Saunders et al 2000) found that females preferred to give birth in areas of low disturbance and that pups born in such areas gained weight more quickly than pups born in areas with greater disturbance. During periods of high human disturbance, females were more protective towards their pups and the pups were more vigilant. The study suggests that these behavioural changes may divert energy away from the pup leading to reduced growth rate and increased pup mortality. However, while able to show an apparent impact of disturbance, the study does not identify any population consequences of human disturbance. The colony has dramatically increased in size since 1990 and the weaning and growth rate of pups was higher than those reported in other colonies.

20.22. Work on grey seals in Wales indicates that disturbance is site-specific, with seal behaviour varying between sites in how seals respond to disturbance

(Westcott and Stringell, 2003). Westcott *et al.* also suggest that there is also variation between individuals in how they respond to disturbance, except when in groups, where extreme reaction by one individual tends to be followed immediately by the group. This has implications for how each site and any disturbance should be managed, implying that site-specific measures may be necessary to minimize disturbance. The authors suggest successful management of seal populations will require creative engagement with the public. Also of interest is the suggestion that disturbance levels at the sites studied have probably varied over time and seals appear to have become habituated to levels of disturbance that, in the 1980s, they would probably not have tolerated.

20.23. In Norfolk, monitoring results highlight the recent increase in numbers of grey seals along the East Anglian coastline and the scarcity of harbour seals (Skeate and Perrow, 2008). The authors suggest that disease has precipitated a decline from which harbour seals seem unable to recover; harbour seals now seem unable to breed on the mainland, "presumably because of the pressure of humans and their dogs".

20.24. The timing of the breeding season is an important consideration within the UK as it varies between sites and on some sites will coincide with peak visitor numbers in the summer. In the Scilly Isles, the breeding season for grey seals begins in July, whereas in south-west England it begins in late August to early September and becomes progressively later in a clockwise direction around the country (Saunders et al., 2000). Harbour seals' breeding and moulting season lasts from June to August coinciding with the 'peak' tourist and recreational season.

20.25. In summary, there is clear evidence that human disturbance can lead to population decline in seals, and this has been clearly shown for species that occur in areas with high human pressure such as the Mediterranean. For both species within the UK there is evidence of disturbance impacts. For harbour seals, a species which has declined markedly and which breeds and moults in high summer, disturbance is of particular concern.

Types of Site with Particular Vulnerability to Access Related Issues

20.26. The original guidance (see para 13.4.1) argues that underground hibernation sites for bats have the highest vulnerability to increased levels of human activity. Two recent studies concur that persistent human disturbance is a major cause for the decline in populations of many cave-dwelling bats and provide advice on gate mitigation mechanisms (Martin et al., 2003;Pugh and Altringham, 2005).

20.27. Recently published studies do not substantively change the assessment in the WAAG 2001 guidance (see para 13.4.2) of site vulnerability for otters, water voles *Arvicola terrestris*, deer or badgers.

20.28. The potential extension of open access to coastal habitats poses a clear potential problem in terms of human disturbance to seal haul-outs and breeding colonies. This is particularly acute given that the breeding and moulting season for the most vulnerable species, harbour seal, coincides with high season for coastal recreation. There will probably be a need for site-specific management measures to mitigate the impacts of disturbance.

Associated Interests

20.29. Seal breeding colonies and haul-out zones may coincide with sites occupied by beach-nesting or wintering waders (particularly at roosts), where management actions may also be in place or open for discussion.

Implications of research

20.30. Management actions may be beneficial for red deer in particularly heavily disturbed areas particularly if it is confirmed that disturbance imposes fitness costs through increasing energy expenditure and decreasing energy gathering (Sibbald *et al.*, 2001). In the light of the finding that dogs cause increase vigilance and aggregations in red deer, there may be merit in considering provisions to maintain dogs on leads around red deer, perhaps at vulnerable periods, such as rutting (Jayakody *et al.*, 2008).

20.31. Findings that Eurasian otters are less likely to occur where greater human disturbance exists strengthens the view in the original guidance (see para 13.6.3) that site management will be necessary to avoid disturbance to holts.

20.32. Recent research stresses the benefits of cave-gates at sites heavily used by bats (Martin et al., 2003;Pugh and Altringham, 2005). It also alleviates any concerns that cave-gates may adversely impact bats (Martin *et al.*, 2003), at least if a minimum spacing between horizontal bars is kept at a precautionary 150 mm (Pugh and Altringham, 2005). These findings would be worth factoring into existing or future site management decisions.

20.33. Site managers and access assessments for coastal sites should consider disturbance impacts to seals. While there is no evidence yet of any population effect arising from disturbance to these two species, there is clear evidence of behavioural impacts that could be expected to impose fitness costs. The most vulnerable period is during pupping and weaning, which unfortunately coincides with the British summer and early autumn, which tend to have higher levels of coastal tourism. Impacts are likely to be particularly significant for the harbour seal, a declining species. While some degree of habituation appears to have been demonstrated by at least one grey seal colony (Saunders *et al.*, 2000) and this species' population is increasing, some form of visitor control is probably necessary to reduce disturbance (Brown and Prior, 1998), with harbour seals in particular.

20.34. Seal colonies are, however, a clear tourist attraction which could bring wider environmental and educational benefits, so, as Westcott *et al.* (2003) point out, successful management of seal populations will require creative engagement with the public. Potential measures to consider at susceptible sites might include setback distances combined with information provision, providing enclosed viewing areas (hides) and locally extending the season for keeping dogs on leads until the seal breeding and moulting seasons are over. Measures to limit access may be warranted at harbour seal colonies in particular.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

20.35. There is no new material relating to CRoW specific exclusion or restrictions in addition to those presented in the original guidance (chapter 13.6).

Related Concerns

20.36. The work showing that red deer respond more to dogs than people on foot, dogs causing increased levels of vigilance and aggregation of the deer (Jayakody *et al.*, 2008), lends support to the suggestion in the original guidance (chapter 13.7) that worrying by dogs can cause animal welfare problems.

Opportunities Associated with a Statutory Right of Access

20.37. no new information.

21. REPTILES AND AMPHIBIANS (HERPETOFAUNA)

Summary

- There has been a review of UK herpetofauna and access impacts, published since 2001. A number of studies from outside the UK have also been published, providing evidence that areas with high levels of access tend to support reduced numbers of reptiles and showing behavioural and physiological consequences of disturbance to reptiles.
- The sand lizard *Lacerta agilis* stands out as the key UK species for which access poses particular concern. This species is highlighted as being particularly vulnerable due to its behaviour, choice of habitat and sites of occurrence.
- The same review also suggests that adders *Vipera berus* may be vulnerable to disturbance, which can disrupt their basking.
- There is also evidence of impacts to natterjack toads *Bufo calamita*. Anecdotal evidence highlights impacts from dogs entering breeding pools, and this causing damage to spawn. Young toadlets, once they emerge from the water are also potentially vulnerable to trampling.
- There is relatively little published material specifically addressing the impacts of horse riding or cycling. Horse riding and heavy trampling can result in direct mortality of adult females sand lizards and their eggs.
- Future research could address the importance of heathland tracks and paths for sand lizards in providing bare ground habitats and the extent to which trampling might have implications at a population scale.

Accessibility of sites with Reptiles and Amphibians

21.1. In this chapter we address additional material relating to reptiles (sand lizard *Lacerta agilis*, common lizard *Lacerta vivipara*, slow worm *Anguis fragilis,* smooth snake *Coronella austriaca*, adder *Vipera berus* and grass snake *Natrix natrix*) and amphibians (natterjack toad *Bufo calamita*, common frog *Rana temporaria*, common toad *Bufo bufo*, palmate newt *Triturus helveticus*, smooth newt *Triturus vulgaris*, and great crested newt *Triturus cristatus*) .

21.2. The two groups occur in a range of different habitats, but freshwater habitats (for amphibians), dunes and dune slacks (for both amphibians and reptiles) and heathlands (for reptiles) are particularly important. Access levels can be high in heathlands and coastal sand dunes. People are often attracted to ponds and water features within sites, and therefore the distribution of all species can coincide with public access.

General Vulnerability of Reptile and Amphibian Sites to Direct Impacts arising from Access

21.3. The original guidance highlights a lack of research. Potential concerns include fish introduction to ponds, fires and collection. There has been new material published since 2001, the most important of which is the work by Edgar (2002), who addresses the potential implications (for amphibians and reptiles in the UK) of increased access associated with the introduction of the CRoW Act (2000). Other work includes three direct studies (from outside the UK) addressing the effects of disturbance on individual species. Two studies from outside the UK have discussed the impacts of collecting, focusing on habitat damage. There is very little on higher rights impacts; some examples of impacts from horse riders and bikes are given in Edgar (2002) and one study has addressed the impacts of off-road vehicles.

21.4. Additional new material comes from the UK BAP. In 2005 lead partners involved in the UK BAP were asked to report on their species and habitats. The reporting included identifying current or emerging threats. Two species, natterjack toad and sand lizard are cited as having current threats potentially relating to access. (Table 8). This highlights that disturbance is clearly an issue for these two priority species.

Table 8: BAP priority reptile and amphibian species (from 2005) where disturbance or housing issues identified as a current or emerging threat. Data are from 2005 BAP reporting round.

Common name	*Habitat loss / degradation from coastal development*	*Habitat loss / degradation from housing infrastructure*	*Habitat loss / degradation from tourist / recreation facilities*	*Human disturbance: Interference / displacement*	*Human disturbance: other recreation / tourism*
natterjack toad					✓
sand lizard	✓	✓		✓	

21.5. Edgar's (2002) review of access impacts for reptiles and amphibians draws on information gathered by a combination of questionnaires, interviews, anecdotal reports from site managers and herpetologists, site case studies and existing literature.

21.6. Edgar identifies the sand lizard as by far the UK herptile most vulnerable to the effects of public access, due to its habitat requirements and biology. Edgar highlights that entire UK population occurs on sites affected by the CRoW Act, with 95% of the population occurring on lowland heathland. Sand lizards are clustered within heathland sites in particular areas of suitable habitats, where mature heather occurs alongside bare sand. Edgar considers that such specific habitat requirements, clustered populations, plus the behaviour of sand lizards (they spend more time basking and are particularly site faithful) means they are vulnerable to disturbance. In addition, the sand lizard is the only British reptile to nest in bare ground, laying between four and twelve eggs in burrows dug by the females in unshaded, bare sand that, on many sites, may only be available along paths and tracks. The nests, 4–10 cm below ground level are believed to withstand light trampling by people, but are vulnerable to heavy trampling.

21.7. Edgar suggests that the adder is also prone to human disturbance, and disturbance from dogs, due to the species behaviour of basking in open locations such as footpaths, clearings etc. Edgar considers the remaining UK reptiles to be largely immune from human disturbance, largely due to the habitats they occur in and their behaviour.

21.8. Edgar considers amphibians generally immune to most public access effects during their terrestrial lives, but the necessity for all species to utilise ponds for breeding purposes exposes them to a greater range of pressures. Because adult natterjack toads are nocturnal and spend the day within burrows (often >20cm deep), Edgar considers impacts from human disturbance, even from trampling by humans or grazing animals, to be minimal. He even suggests that trampling may sometimes be beneficial in maintaining areas of open sand. It is the breeding season that disturbance effects may occur for this species. They prefer temporary ponds and the shallow water means their spawn is vulnerable, especially to dogs running through the ponds. Dogs entering the pools disturb the silt which then rests on the spawn strings leading to the development of a fungus *Saprolegnia* spp (A. Kimpton *pers. comm.*). Dogs running through the water also take spawn strings with them and may drink tadpoles, particularly if the water table drops. People visiting the pools at sites such as Ainsdale (Edgar, 2002, Kimpton pers. comm) can tread on emerging toadlets in early summer.

21.9. Work on disturbance in northern Italy looked across a range of small woodland patches with different levels of human activity and use (Ficetola *et al.*, 2007). Two reptile species (western whip snake *Hierophis viridiflavus* and the wall lizard *Podarcis murali*) and one amphibian (green toad *Bufo viridis*) occurred in at least 10 patches. The occurrence of both reptile species within a given patch was negatively related to the amount of human activity recorded in each patch. The occurrence of the toad and reptiles (as a class) was negatively related to litter disturbance, a consequence of trampling and heavy use of the woodland patches, especially from events.

21.10. In a study of the endemic Iberian frogs *Rana iberica*, Rodriguez-Prieto *et al.* (2005) found that frog abundance decreased with the proximity to recreational areas. The authors simulated different access levels along streamside banks and recorded an 80% and 100% decrease in stream bank use with a fivefold and a 12-fold increase in direct disturbance rate, respectively.

21.11. The mechanisms by which human disturbance may impact herpetofauna are complex. Kerr *et al*. (2004) used activity loggers to record body temperature and stride frequency of Australian sleepy lizards *Tiliqua rugosa* subjected to different levels of disturbance (observed only, briefly handled and held for an extensive period). Following all disturbance types, there was an increase in average stride frequency that lasted for up to an hour, a significant period for an animal that is generally active for only a few hours in the day. The extent of this effect increased with the level and duration of the disturbance.

21.12. Work on wall lizards in Spain has found health implications of disturbance (Amo *et al.*, 2006). Lizards inhabiting areas with high tourism levels showed higher intensity of infection by ticks and lower body condition at the end of the breeding period. Moreover, lizards with poorer body condition had lower cell mediated immune responses suggesting that tourism has deleterious effects on body condition and on host–parasite relationships in this species.

21.13. Collection and direct persecution of reptiles and amphibians may still be an issue. Natterjack toad spawn has been collected by the public (mainly children) at Ainsdale (A. Kimpton *pers. comm.*) and Edgar (Edgar, 2002) cites some other examples of the public collecting reptiles. There is evidence from abroad showing that collection of reptiles can cause habitat damage (Goode et al., 2004;Goode et al., 2005). Direct persecution of adders is rarely reported (Edgar, 2002).

21.14. Various indirect effects of public access as important (Edgar, 2002). Uncontrolled fires can kill many reptiles, and on heathland sites recolonisation from adjacent unburnt areas can take from 5–25 years (see Underhill-Day, 2005). In terms of amphibian conservation, the introduction of invasive aquatic plants into ponds, as well non-native animals such as exotic fish and terrapins, is extremely detrimental (Edgar, 2002).

21.15. There is little evidence of impacts resulting from horse riding or cycling. There is anecdotal evidence that sand lizard nests on heathland tracks have been destroyed by horse riding and mountain biking (Edgar, 2002).

Types of Site with Particular Vulnerability to Access Related Issues

21.16. The original guidance identifies the following types of sites as those with particular vulnerability to access related issues:

- Sites with access routes close to key breeding sites, basking areas or foraging areas for sand lizard and natterjack toad;
- There might also be similar but lesser concerns for smooth snake, adder and great crested newt sites. Because of the specific habitat requirements of these species, damage from trampling may occur.

21.17. The new evidence essentially supports the original guidance. Sand lizards are clearly vulnerable, and it is foci, typically found on south-facing mature or degenerate dry heath with a diverse vegetation structure and unshaded, predominantly south-facing areas of exposed sand (Edgar, 2002) that are important. Such areas will be vulnerable, especially to excessive trampling or access by bicycle or horse.

21.18. Pools used by breeding natterjacks are typically shallow, often temporary pools in dune systems or heathland. There is evidence that dogs swimming in such sites can have an impact.

Implications of research

21.19. Horse riding and mountain bike use on sites with sand lizards should be carefully controlled during the breeding season (May - Sept; following the guidance in the heathland management calender, see Moulton and Corbett, 1999).

21.20. Dogs accessing water-edge habitats is an issue of concern, especially on sites where natterjack toads are present.

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

21.21. Restrictions relating to dogs on leads (thereby preventing dogs accessing water-edge habitats) may be necessary on sites where natterjack toads are present.

Related Concerns

21.22. Reptiles and amphibians are difficult to monitor (e.g. Reading, 1997), and, crucially, high levels of mortality do not necessarily lead to population declines (Beebee and Griffiths, 2005). Without an understanding of the population consequences of disturbance, it is impossible to identify the true scale and relative importance of access impacts.

21.23. Looking across the range of literature available there is anecdotal evidence of disturbance impacts, and some clear studies from outside the UK showing reductions in the number of animals in areas where disturbance levels are high.

22. INVERTEBRATES

Summary

- Many invertebrates are associated with early successional habitats, sometimes requiring a very specific niche in terms of habitat structure or type. Access, through trampling and increased erosion, can clearly have a role in maintaining some of these habitats. There are many invertebrate species that typically occur on paths, tracks or other areas of bare ground.

- There is also evidence that trampling, disturbance and increased erosion resulting from access can have a detrimental impact. Associated activities such as car-parking and cleaning (e.g. beaches and woodlands) may also be detrimental. There is evidence of impacts on heathland, shingle, grassland, sand dunes and woodlands.

- Available literature sheds little light on two key issues: the population consequences of access and the level of access that would benefit different habitats. Impacts of access may be site-specific, depending on factors such as size, degree of fragmentation etc. The implication is that access impacts for invertebrates should be assessed at a site scale.

- There is relatively little information on the impacts of horse riding or cycling. Horse riding can clearly have detrimental impacts for some species, caused by the trampling impact of the hooves. Most examples come from heathlands. High mortality of adult beetles in a sand dune site in France has been attributed to cycles.

- There is scope for further work on invertebrates and access, including studies to address the relative importance of access in maintaining early successional habitats, and the potential role of paths as barriers to invertebrates.

Introduction and Context

22.1. The original guidance focussed largely on trampling, which can: cause direct mortality to invertebrates; increase soil compaction; and reduce litter, vegetation height and usually the diversity of plant species. These can all impact on invertebrates. The scale of the impact will depend on the soil and vegetation type (see chapter 3.3. of the original guidance). Loss of flowers and of floral diversity will reduces the availability of nectar or pollen and the reduction in height and changes in structure would affect species requiring taller vegetation.

22.2. The original guidance largely draws from papers that are more than 20 years old, and found relatively few studies that addressed trampling directly. The research highlighted in the original guidance suggests that trampling in woodland, grassland and sand dunes significantly reduces the invertebrate fauna across most groups. In the grassland study, light trampling (5–10 tramples/month) was enough to cause a reduction in the number of species present in grass litter.

22.3. Besides trampling other impacts highlighted included the barrier effect of tracks on invertebrates, collecting and disturbance to logs and boulders.

22.4. There is much new anecdotal material, principally from the BAP reporting rounds, field surveys and unpublished survey reports. Such material often highlights disturbance, trampling or access as issues for particular species. Another new source is a large publication addressing habitat management for invertebrates (Alexander et al., 2005k) . There are also now more robust studies specifically addressing disturbance. New material includes work from Flemish sand dune systems specifically looking at recreational disturbance, and a large volume of work on sandhoppers and other sandflat invertebrates. Finally, we also draw from pre-2001 material that may have been overlooked when compiling the original guidance.

22.5. All species listed within this chapter as example are classified as Red Data Book or nationally scarce species, unless otherwise stated.

General Vulnerability of Invertebrate Sites to Direct Impacts arising from Access

22.6. Disturbance issues has been identified as threat for a number of BAP priority invertebrates (Table 9), and this provides a useful indication of the kind of species and sites where disturbance is an issue (although we note that the assessment is now dated, as the BAP list has now since substantially updated but threats have not yet been identified for the new species). Lack of disturbance is cited as a threat for six species. These disturbance-dependent species (Warren and Buttner, 2006;Warren and Büttner, 2007;Warren et al., 2007) typically require bare ground or early successional habitats. Trampling is cited as a threat for three species:narrow-headed ant *Formica exsecta*, belted beauty *Lycia zonaria* and mottled bee-fly *Thyridanthrax fenestratus*. The ant and fly are both heathland species; belted beauty is a moth associated with early successional dune grassland, where habitat quality appears to be important (Howe et al., 2004).

22.7. This overview of BAP priority species highlights heathland, sand dune and shingle habitats as being habitats where access is an issue for invertebrates.

Table 9: BAP priority invertebrate species (from 2005) where disturbance or housing issues identified as a current or emerging threat. Data are from 2005 BAP reporting round.

Species	Habitat loss / degradation				Human disturbance		
	from coastal development	from housing infra-structure	from tourist / recreat-ion facilities	from lack of disturb-ance	from military use / disturb-ance	from other recreation / tourism	from trampling (physical damage)
Fiery Clearwing	✓						
a Solitary Wasp *Cerceris quadricincta*		✓					
a Solitary Wasp *Cerceris quinquefasciata*				✓			
Heath Tiger Beetle				✓			
Basil-thyme Case-bearer				✓			
Speckled Footman				✓			
Striped Lychnis				✓			
Marsh Fritillary		✓					
Netted Carpet		✓		✓			
Narrow-headed Ant							✓
Buttoned Snout		✓					
Bright Wave		✓					
Belted Beauty						✓	✓
a Click Beetle *Melanotus punctolineatus*			✓				
Gilkicker weevil					✓		
Flixweed leaf beetle		✓					
Mottled Bee-Fly			✓				✓
Four-Spotted Moth				✓			
Slender Scotch Burnet				✓			

22.8. Access can result in damage to the fabric of habitat, such as soil compaction or enhanced erosion. Bare ground and early successional habitats are critical for many species of invertebrate, where the quality of the substrate and types of adjacent vegetation are crucial characteristics (e.g. Kirby, 1992;Key, 2000). Given that such habitats often coincide with where access takes place (e.g. along paths or tracks), they could be vulnerable to changes in access levels.

Heathlands

22.9. Some of the most important habitat features for invertebrates on lowland heath are bare or sparsely vegetated patches of ground (Kirby, 1992;Key, 2000); these are often associated with unsurfaced paths. Key (2000) highlights that by far the majority of scarce species associated with the Dorset heathlands are associated with bare ground rather than heathland vegetation. The variety of species associated with bare ground is considerable, for example there is an assemblage of c. 180 species of aculeate Hymenoptera (bees, wasps and ants) associated with bare ground on heathlands (Miles, 2006). Bare ground provides a range of functions, including nesting sites, foraging habitat and also basking surfaces for thermophilic species such as the mottled bee fly *Thyridanthrax fenestratus* (Stubbs and Drake, 2001).

22.10. The presence of bare or sparsely vegetated paths and tracks provides an important habitat component within many heathland sites. Indeed, this is “likely to be crucial” to the conservation of species such as the heathland hoverfly *Paragus tibialis* (Falk, 1991b).

22.11. A number of other heathland flies benefiting from unsurfaced paths and access on heaths maintaining bare ground or sparse vegetation are identified by Alexander *et al.* (2005f). The same publication also highlights a large number of bees and wasps which benefit from the same management, these include: *Halictus confusus*, the solitary bee *Lasioglossum sexnotatum* , the nomad bee *Nomada signata*, ruby-tailed wasp *Hedychrum niemelai*, and the solitary wasp *Methocha articulata* and large velvet ant *Mutilla europaea*.

22.12. *Scythris empetrella* is a micro-moth whose distribution in the UK includes one site in the New Forest, Findhorn and the Dorset Heaths (P. Sterling *pers. comm.*). It is associated with soft wind blown sand and heather. Within the Dorset Heaths *Scythris empetrella* occurs at Studland and Hengistbury (both coastal sites with very high levels of access, where both wind and access levels will play a role in maintaining soft sand) and at an inland heathland site where gravel extraction still takes place. *Scythris empetrella* has disappeared from a number of inland sites, with the lack of soft loose sand likely to be a factor in the local extinction at particular sites (P. Sterling *pers. comm.*). This example highlights the very narrow niche of some heathland invertebrates, niches which may well be maintained in some circumstances by access.

22.13. Access may therefore be an important mechanism to maintain early successional habitats on heathland sites, but there are cases where access levels can be damaging, especially from horse riding or bikes. Detrimental impacts from intensive public pressure have been identified for many heathland invertebrates (Alexander *et al.*, 2005f), for example intensive trampling can be very damaging for species such as the spiders *Enoplognatha oelandica* and a mesh webbed spider *Lathys stigmatisata*.

22.14. The mottled bee-fly depends on the nesting success of its host wasp *Ammophila pubescens* which nests in hard, bare sand. Most nesting locations for this wasp are in and along the sides of unsurfaced paths, ideally with tall ling *Calluna vulgaris* adjacent to the path (S. Miles *pers. comm.*). Paths that are too heavily used (i.e. churned substrate of soft sand) are unsuitable, as the wasp cannot burrow or relocate previously dug burrows. Burrows can also be crushed by horse riding or cycles (S. Miles *pers. comm.*). Another bee-fly, the heath bee fly *Bombilius minor* is dependent on different hosts, solitary bees of the genus *Colletes*. These bees nest in vertical faces, often associated with banks, cuttings or eroded sides of paths (S. Miles *pers. comm.*). Erosion may therefore be beneficial in providing nesting locations for the host.

22.15. Horse riding has been implicated as a major factor in the severe decline of the heath tiger beetle *Cicindela sylvatica* in England. Horses' hooves churn up sandy heathland tracks making the habitat unsuitable for the beetle. Excessive disturbance from horse riding and motorcycle activity has also been identified as a threat to a large number of aculeate Hymenoptera, including the following UKBAP Priority Species: dark guest ant *Anergates atratulus*, narrow headed ant *Formica exsecta*, red barbed ant *Formica rufibarbis*; a mining bee *Andrena ferox*, banded mining bee *Andrena gravida*, a cuckoo bee *Nomada ferruginata*, shrill carder bee *Bombus sylvarum;* ruby tailed wasp *Chrysis fulgida*, Purbeck Mason Wasp *Pseudepipona herrichii* and a solitary wasp *Cerceris quinquefasciata* (UK Biodiversity Group, 1999a;UK Biodiversity Group, 1999b;Alexander et al., 2005f).

22.16. The Purbeck mason wasp is of particular interest as it a very rare species limited to a small number of sites within Dorset (Roberts and Else, 1997). It has been expanding in recent years (Roberts *pers. comm.)* and occurs on a number of tracks and paths. It is associated with clay or sandy clay in which it constructs its brood chambers, and the substrate is crucial. Annual monitoring has found few impacts of access (Roberts, 2003, Roberts pers. comm), despite many of the colonies occurring on tracks. However, impacts of horse riding have been noted from at least one nesting site. On Godlingston Heath, increased passage of horses from local riding schools over at least three years along one section of permissive bridleway resulted in the substrate being broken down and becoming increasingly sandy. This resulted in the habitat being unsuitable for nesting.

22.17. The surfacing of paths with aggregate or tarmac is a threat to species associated with bare ground and open mosaic habitats. Resurfaced paths can also act as barriers to dispersal for less mobile invertebrates. The decline of the heath bee-fly *Bombylius minor*, mottled bee-fly, and heath tiger beetle on lowland heathland sites has been attributed to the hard surfacing of paths and tracks to prevent erosion (Telfer, 2005;Miles, 2006).

22.18. Increased fire incidence is a feature of heaths with high levels of access and the impact of fire on invertebrates can last many years (see Underhill-Day, 2005 for review). Soil enrichment from dog fouling is another impact of access particularly associated with this habitat (Shaw et al., 1995;Alexander et al., 2005f;Taylor et al., 2005;Underhill-Day, 2005).

Woodlands

22.19. Two studies have addressed trampling in urban woods in Finland (Grandchamp et al., 2000;Lehvävirta et al., 2006). The impacts of trampling appear to be subtle, and to some extent confounded by habitat patch size and degree of habitat fragmentation. It was only in the interior of large sites that the authors consistently found the same species/species groups, suggesting variation increased with human pressure and distance from the edge (Lehvävirta et al., 2006). The initial study (Grandchamp *et al.*, 2000) found there was a positive correlation between the number of carabids captured and the amount of trampling, suggesting more beetles occurred where trampling intensity was greatest. However there was no correlation between species richness or diversity index and trampling intensity.

22.20. A number of other studies have looked at carabid abundance in woodlands along an urban gradient (Alaruikka et al., 2002;Magura et al., 2004;Sadler et al., 2006). In a UK study centred around Birmingham (Sadler et al., 2006), species richness and diversity were lower in the urban and suburban zone and higher in the rural zone. At the site level, the carabid assemblages were related to the level of site disturbance and soil penetrability. Site size and amount of woodland and urban land within 5 km of the site were important at a landscape scale.

22.21. On sites with public access, bark stripping and breaking up rotten wood can do considerable damage to the invertebrate fauna (Kirby, 2001). Removal of deadwood and dead and rotting trees is a major threat to saproxylic (deadwood) invertebrates (Kirby, 2001;Alexander et al., 2005g;Alexander et al., 2005h;Alexander et al., 2005i;Alexander et al., 2005j). This micro-habitat is often removed for health and safety reasons and also by the public for camp fires etc.

Grasslands

22.22. The original guidance illustrates how access can be damaging to grassland habitats. There are also examples where access may be beneficial in grassland habitats. There is a range of grassland species that are associated with bare ground and open vegetation which access may maintain. These include a number of bees and wasps associated with chalk downland (Alexander *et al.*, 2005d) such as nomad bee *Nomada signata*, scabious bee *Andrena hattorfiana* and another mining bee *Andrena tibialis*. The ground bug *Heterogaster artemisiae* is associated with thyme *Thymus drucei* on coastal dunes, cliff tops and chalk grassland. This ground bug seems to show a preference for areas with broken or partly bare ground or scree, or the edges of tracks, where there are large clumps of thyme over bare ground or stones (Kirby, 1992). Thyme growing in closed turf appears to be unsuitable, and light disturbance from public access and recreation may maintain suitable conditions for this species.

22.23. There are similar habitat requirements for a number of species of lowland acid grassland; indeed, there is much species crossover between different grassland habitat types. Species benefitting from light disturbance from access include the mining bees *Andrena ferox* and *Andrena gravida* and the solitary wasp *Cerceris quinquefasciata* (Falk, 1991a;Alexander et al., 2005e). Appropriate management for these species allows light disturbance, e.g. from walkers, but controls or prohibits excessive disturbance from activities such as horse riding and motorcycling (Alexander *et al.*, 2005e).

Rocky Shores

22.24. Various studies have found trampling damage to rocky shore fauna, with both macrofauna (some bivalves, anemones, barnacles, limpets, whelks, sea stars, amphipods, polychaetes, isopods, oligochaetes and gammarids) and meiofauna (nemotodes, ostracods, acarids, tanaids, some bivalves, polychaete, oligocheate and annelid worms, sponges and caprellid amphipods) reduced in number in trampled areas (Casu et al., 2006a;Silbernagel, 2008). Some species are immediately affected by trampling and show rapid declines; these include some nematode worms, mites, bivalves, gammarid shrimps, sea urchins, isopods and polychaete worms (Casu et al., 2006c). Some studies have found that polychaete worms were particularly sensitive to trampling effects and took longer to recover than other groups (Brown and Taylor, 1999;Casu et al., 2006b).

22.25. Not all studies have demonstrated effects of disturbance on barnacles, limpets and whelks (Jenkins et al., 2002;Beauchamp and Gowing, 2003), but heavy trampling reduced the density of mussels (Van de Werfhorst and Pearse, 2007;Smith et al., 2008). In one long term study, the density of all species studied (except small gastropods) declined over time (Addessi, 1994).

22.26. Damage to communities tends to be greatest closer to main access points (Addessi, 1994). The damage may be less where people are barefoot, and one study found 85% of those visiting the rocky shore used no footwear (Bally and Griffiths, 1989).

22.27. There seem to have been few studies on the effects of harvesting on rocky shores. The main species are shellfish, crustacea and sea urchins for bait or food, and the general effect of over-harvesting is to reduce populations and remove old adults. As most of the collected species are broadcast spawners, relying on the release of huge numbers of eggs or larvae, the population relies on a high number of fertile individuals to optimise reproductive effort, and this can therefore be seriously compromised by unwise harvesting (Murray *et al.*, 1999). Harvesting can also change the relationships of predator and prey, leading to a decline in predator numbers or to over predation of a reduced population and a switch to dominance by other species. Where human harvesting of a muricid gastropod predator of mussel beds was stopped, there was a switch to dominance by barnacles and an increase in species diversity as predation of the mussel beds increased (Duran and Castilla, 1989).

Sand dunes

22.28. Reviews of spiders published since the original guidance (Harvey et al., 2002;Alexander et al., 2005b) list a number of coastal dune species potentially threatened by human access. These include: a running foliage spider *Agroeca lusatica*, a comb-footed spider *Enoplognatha oelandica*, a money spider *Trichopterna cito*, the jumping spiders *Phlegra fasciata*, *Marpissa nivoyi* and *Synageles venator* . All are rare species associated with dune systems: for example, *A. lusatica* is currently known from only two sites in Kent (Russell-Smith, 2006).

22.29. Negative impacts of public access have also been identified for a number of flies associated with sand dunes (Falk, 1991b;Alexander et al., 2005b;Falk and Ismay, in prep). Consequent recommendations include restricting access through the use of defined paths, boardwalks and fencing where necessary. Relevant species listed include: a grass fly *Conioscinella zetterstedti* , a fly *Parochthiphila coronata*, a dune snail-killing fly *Salticella fasciata* (RDB2), a snail-killing fly *Psacadina verbeke*i, a shore fly *Psilopa marginella*, a picture-winged fly *Pteromicra glabricula* and a two-winged fly *Tetanops myopinus*. These are all species with recent records from only a limited number of locations in the UK. Access-associated disturbance and trampling have also been identified as a threat to the shieldbug *Geotomus puntulatus* at its only UK site in west Cornwall (Nau, 2005a).

22.30. Recreational pressure is identified as a threat to a large number of aculeate Hymenoptera particularly from trampling or erosion: species identified by (Falk, 1991b;Alexander et al., 2005b) include the UK BAP priority species the spider-hunting wasp *Evagetes pectinipes*, northern colletes *Colletes floralis*, brown-banded carder bee *Bombus humilis*, shrill carder bee *Bombus sylvarum*; and red data book species of ant *Myrmica specioides* and *Solenopsis fugax*, the wasps *Arachnospila consobrina, Tachysphex unicolor*, *Miscophus ater*, *Mimesa bicolor*, *Mimumesa littoralis*, *Colletes cunicularis*, *Hylaeus spilotus*, *Andrena alfkenella*, the cuckoo bees *Coelioxys mandibularis* and *Coelioxys quadridentata*, the bees *Anthophora retusa*, and ruby tailed wasps *Cleptes nitidulus* and *Hedychrum niemelai*.

22.31. By contrast, there are some species for which recreation pressure may be a benefit, in that it maintains open habitats. An example is the fly *Trixoscelis marginella*, a species associated with sparsely vegetated sandy areas on heaths and coastal dunes (Falk, 1991b). The ant-lion *Eurolean nostras* has some association with dune paths at its main site in Suffolk. Larvae construct pits under overhanging vegetation or ledges, or where roots of bushes provide shelter. Only rarely are pits directly exposed to the sky. In sand dunes, pits are typically constructed at path edges where eroding banks create overhangs for shelter. While trampling and disturbance from public access is a direct threat to nesting aggregations (Plant, 1998), it also is important in maintaining suitable habitat.

22.32. A number of species of aculeate Hymenoptera are associated with sandy paths or areas of moderate disturbance (Falk, 1991b;Alexander et al., 2005b), these include: the solitary bee *Andrena alfkenella*, the cuckoo wasp *Hedychridium cupreum* and *Hedychrum niemelai*, *Dasypoda hirtipes,*, the solitary bee *Andrena humilis* and the wasp *Methocha articulata*. Limited disturbance may be of benefit for these and species with similar requirements.

22.33. A number of ground beetles (Carabids) may benefit from controlled public access on sand dune systems. The tiger beetles *Cicindela hybrida* and *Cicindela maritima* are often associated with sandy pathways (Luff, 1998;Telfer and Eversham, 2000): it is possible that the correct level of trampling can create suitable conditions (ground which is neither too heavily compacted nor too loose and churned up) for larval burrows (Alexander *et al.*, 2005b). However, access has been shown to impact on behaviour for tiger beetles in Turkey (Arndt *et al.*, 2005). Arndt *et al.* looked at three different dune areas with varying levels of human activity. The activity of adult tiger beetles diverged during the tourist season, decreasing markedly with increase disturbance. Larval activities showed similar trends, with first and second instar larvae were practically absent from the heavily disturbed section. Observations of *C. hybrida* in France noted a high mortality of adults on a well used cycle track across dunes, due to crushing by bike tyres (Alexander *et al.*, 2005b). Clearly there are levels, and types, of access that may have impacts for this genus.

22.34. There are few Lepidoptera for which access is a potential issue. Least owlet *Scythris siccella* is a moth currently confined to a small strip of land (c.1m by 100m) in Dorset that currently receives reasonably heavy trampling pressure from people accessing a beach area popular for windsurfing. It is a good example of a species confined to a very limited area that is also subject to considerable access pressure. The species is associated with areas of loose sand in which it makes its larval tubes feeding on low-growing plants lying on the surface. Some trampling may be needed to maintain the open conditions through disturbance, but too much trampling is likely to be a problem (M. Parsons *pers. comm.,* P. Sterling, *pers. comm*). Boardwalks have been built in the area and in areas adjacent to the boardwalk the sand areas do seem to be stabilising, potentially making the habitat less suitable for the species. Levels of access within a very limited area seem critical.

22.35. Another example of a species within very limited distribution is the belted beauty *Lycia zonaria*. At Morfa Conwy in Wales, the species faces imminent extinction primarily because of the loss of semi-fixed dune grassland to succession (Howe et al., 2004). Numbers have dwindled due to succession, and the core population is now found on an area open to high human pressure (from walkers, dogs and picnickers), where the larvae and adults are very vulnerable to trampling (M. Howe *pers. comm.*). In this example, succession has caused a change in distribution of the species, highlighting the dynamic nature of sand dunes. Access routes may remain relatively constant in an area, but the area and location of different habitats may change over time.

22.36. It is clearly difficult to generalise between species, groups and sand dune sites. Moreover, for many sand dune invertebrate species it is difficult to untangle the importance of access levels in modifying habitats from the direct impacts of trampling and disturbance. Work in Belgium on the digger wasp *Bembix rostrata* has revealed clear impacts of disturbance (Bonte, 2005). Nesting densities of the wasp declined dramatically with increasing trampling from people and cattle. The trampling from people resulted similar environmental conditions compared to natural disturbance, yet significantly affected local population sizes of the wasp. The trampling by people did not significantly alter the structure of the habitat yet did have an impact on the wasp. Bonte suggests that disturbance interacts with the wasps' behaviour and destroys unfinished nests, preventing females from retrieving larvae. In this example, high numbers of people in the dunes coincided with peak wasp activity. The timing was critical as the access from people was occurring at a time of year when natural disturbance would be limited (calm weather) and the dunes were not normally grazed with cattle.

22.37. Bonte (Bonte, 2005) suggests that tolerance to disturbance is species-specific and related to life history characteristics. He argues that human disturbance should not be accepted simply because a species involved is known to be tolerant of natural disturbance. Bonte also suggests that it is not possible to make generalisations between species.

22.38. Even for a given species, the impacts of sand dune access may be site-specific. Further work by Bonte *et al*. in Belgium (Bonte and Maes, in press) examined occupancy patterns of five different invertebrates during two successive years in 133 grey dune fragments and found that disturbance impacts were greater on small, fragmented patches. This work highlights that the impacts of disturbance cannot be assessed in isolation.

22.39. Permitting car parking on dune grasslands is also identified as an impact of public access which is detrimental to a number of invertebrate species (Alexander *et al.*, 2005b). This threat is more explicitly identified for a UK BAP priority species the click beetle *Melanotus punctolineatus* (Alexander *et al.*, 2005b).

22.40. Beach cleaning is also an issue associated with access in these habitats. Strandline species are sensitive to the removal of tidal debris through beach cleaning operations: these include: the spider *Drassyllus lutetianus* (Na) (Harvey *et al.*, 2002); the Staphylinid beetles *Phytosus nigriventris, Omalium rugulipenne* and *Heterota plumbea* (Hammond, 2000); beach comber beetle *Eurynebria complenata*; and the pill woodlouse *Armadillidium album*. Management should avoid such 'tidying up' operations and aim instead to reduce public disturbance of drift material or the collection of driftwood (Alexander et al., 2005b;Whitehouse et al., in prep).

Shingle

22.41. A list of invertebrates associated with coastal vegetated shingle are given in Doody and Randall (2003) and Shardlow (2001).

22.42. Shingle is an important habitat for invertebrates in the UK, supporting a large number of rare or scarce species. Disturbance has a negative impact on the majority of invertebrates (Shardlow, 2001), an assessment supported by Kirby (2001): that: "public access to shingle habitat is probably always damaging to some extent. Shingle communities are easily damaged by trampling because of the instability of that habitat." Off-road vehicle access has been identified as a threat to invertebrates on some sites (Alexander *et al.*, 2005c).

22.43. The looping snail *Truncatella subcylindrica* has been found in shingle and rotting vegetation. Physical disturbance of the habitat by walkers and vehicles, even at a low level, has been identified as a threat to this species (Alexander *et al.*, 2005c). Good management will aim to prevent physical disturbance to the gravel where this species occurs. This management also applies to the lagoon snail *Paludinella littorina* (Killeen and Light, 2002).

22.44. Similarly, management recommendations for the carabid beetles *Harpalus serripes* and *Trechus fulvus* state that areas of undisturbed shingle must be maintained limiting access to vehicles and people on foot (Alexander *et al.*, 2005c).

22.45. Strandline species are sensitive to the removal of tidal debris through beach cleaning operations. The strandline fauna is heavily influenced by substrate, shingle species include: the scaly cricket (*Pseudomogoplistes squamiger*), the spider *Pseudeuophrys obsoleta* and the woodlice *Miktoniscus patiencei*, *Trichoniscoides saeroeensis*, *Halophiloscia couchi* and *Stenophiloscia zosterae*. Management should aim to reduce public disturbance of drift material or the collection of drift wood and avoid any attempts to "tidy up" the material (Alexander et al., 2005c;Whitehouse et al., in prep).

Maritime Cliffs

22.46. Cliff habitats are largely inaccessible, and there are few species of invertebrate for which disturbance is mentioned in the literature. One study (McMillan *et al.*, 2003) has addressed the impacts of climbing on snails on inland cliffs in Ontario. They found snail density, richness, and diversity to be lower along climbing routes than in unclimbed areas, and community composition differed between climbed and unclimbed samples.

22.47. Erosion as a result of footfall on the southwest coast path has been identified as a threat to the seed bug *Pterotmetus staphyliniformis* which is only found on a short stretch of cliff top grassland in west Cornwall (Nau, 2005b).

Mudflats, Sandflats and Beaches

22.48. Trampling of mudflats leads to changes in invertebrate community structure (Chandrasekara and Frid, 1996). The mechanical disturbance of trampling can bury animals living on the surface and also bring deep burrowers to the surface. Footsteps can also destroy animal burrows and physically crush or damage animals below the surface. Trampling also alters the surface topography of the mudflats, which can indirectly affect recruitment and spatial distribution of microalgae (Wynberg and Branch, 1994) and macrofauna (see Rossi et al., 2007 and references therein). Furthermore, compaction of the sediment might alter the exchange of nutrients and oxygen between the sediment and the overlying water, change sediment accumulation rate and, again, modify population dynamics and distribution of animals in the mudflat (Rossi et al., 2007).

22.49. In a study of trampling effects on mudflats in the Netherlands, trampling had clear impacts on the macroinvertebrate fauna (Rossi et al., 2007). Trampling resulted in reduced abundance of the adults of a clam species, the Baltic macoma *Macoma balthica* and cockles *Cerastoderma edule*. It was believed that footsteps directly killed or buried the animals, provoking asphyxia. Conversely, for the clam trampling indirectly enhanced the rate of recruitment, while small-sized cockles did not react to the trampling. The number of small animals showed little change because trampling occurred during the growing season and there was a continuous supply of larvae and juveniles. In addition, trampling might have weakened negative adult-juvenile interactions between adult cockles and juvenile clams, thus facilitating the recruitment. This work suggests that during the growing season recovery can be fast, but in the long-term it might lead towards a shift in community dynamics, possibly affecting ecosystem functioning.

22.50. Work on nematodes in mudflats has shown that nematode abundance and species composition to be reduced on trampled plots, but that recovery is rapid (36 hours), suggesting that the nematodes respond to the trampling by burrowing more deeply and soon return (Johnson et al., 2007).

22.51. The effects of varying intensities of human trampling on sandy beach macrofauna were investigated experimentally in South Africa (Moffett et al., 1998). Vigorous beach games (volleyball) resulted in damage to the four species (two mussels, a mysid shrimp and an isopod) studied. One of the mussel species was particularly vulnerable to the trampling, with 18% of individuals damaged in the treatment with the highest intensity of trampling. The results indicated that few members of the macrofauna were damaged at low trampling intensities but substantial damage occurred under intense trampling.

22.52. Sandhoppers on lower beaches have been a focus for a number of studies. Declines in densities of sandhoppers on sandy beaches in Poland have been attributed to tourist pressure and the number of people on the lower beaches (Weslawski J.M. et al., 2000), with similar results in Spain and Brazil (Veloso et al., 2008). Veloso found higher densities sandhopper in protected areas where access was controlled, in both countries. Different species were involved in Spain and Brazil and the beaches differed in the variation in access through the year, yet impacts of access were found at both locations. Ugolini *et al* (2008) found a negative correlation between sandhopper abundance and the number of people at given locations. The people were counted from very specific areas (within 150 m of the sandhopper sampling locations) across a range of different beaches. They also included a number of other variables, included substrate size and trace metals in their analysis and conducted experimental trampling of sandhoppers. Their work shows a clear and very strong trampling effect for this invertebrate group. Some evidence from Spain demonstrates differences in the morphology of sandhoppers on busier beaches (Barca-Bravo et al., 2008), with greater asymmetry among sandhoppers at the site with the most tourist and urban pressure.

22.53. The reduction in invertebrates on tourist beaches is likely to be a result of direct mortality from trampling and also through habitat modification, which on many heavily used beaches may include beach cleaning. A study of coastal systems in the Mediterranean and Baltic (Gheskiere et al., 2005) shows that upper beaches heavily used by tourists are characterised by a lower proportion of total organic matter, lower densities of invertebrates, lower diversities (including absence of certain insects and nematodes) and higher community stress compared to nearby non-tourist locations. The proportion of total organic matter was found to be the single most important factor for the observed differences in the faunal assemblage structure at tourist versus non-tourist beaches.

22.54. In both sand- and mud-dominated habitats, the intensity of the trampling is important (Chandrasekara and Frid, 1996;Moffett et al., 1998), with relatively little damage at low trampling intensities.

Saltmarsh

22.55. The looping snail *Truncatella subcylindrica* has been found at the upper limits of saltmarshes in gravel and rotting vegetation. Physical disturbance of the habitat by walkers and vehicles, even at a low level, has been identified as a threat to this species (Alexander *et al.*, 2005a). The lagoon snail *Paludinella littorina* may also occur in saltmarsh and is also sensitive to physical disturbance caused by access (Killeen and Light, 2002).

22.56. Some mild trampling exposing areas of bare mud may be of benefit to some flies associated with saltmarsh, these include the cranefly *Dicranomyia complicata* (RDB2) (Alexander *et al.*, 2005a). Path construction on the upper saltmarsh has been identified as a threat to species in this transitional zone, and to freshwater seepages and their associated species (Alexander *et al.*, 2005a).

22.57. As with other coastal habitats, saltmarshes feature a terrestrial invertebrate assemblage associated with accumulated tidal debris and driftwood. Management should aim to reduce public disturbance of drift material or the collection of driftwood and avoid any attempts to “tidy up” the material.

Soil Invertebrates

22.58. In a study of cattle trampling and its effects on soil invertebrates (Cole et al., 2007), trampling strongly reduced the abundance, diversity, and species richness of oribatid mites, Collembola and the microarthropod community but had little effect on predatory mites (Mesostigmata). While not directly addressing horse riding, the study may have wider relevance and reinforces some of the studies included in the original guidance.

Collecting/Disturbance

22.59. A revised code for collection of invertebrates has been published since the original guidance (Invertebrate Link (JCCBI), 2002).

Type of Sites with Particular Vulnerability to Access Related Issues

22.60. The original guidance identified a number of site features, such as sites with species that are nationally rare or sites with fragile habitats, which would potentially give grounds for concern regarding access. With respect to trampling damage, the original guidance suggests that, a rare species would only be affected significantly if a path or trampled area coincided with the known, limited habitat in which it occurred, or on which it depended at some time in its life history. The importance of making site-by-site assessments is recognised.

22.61. The importance of site-specific judgement is clear, and more recent publications, such as the work on Flemish sand dune invertebrates (Bonte and Maes, in press), supports this approach. We would also add that there are particular habitats and features within sites that will be particularly important for invertebrates, and that these habitats should be recognised, and access levels and impacts potentially monitored. Simply using species’ distributions to focus attention may be inappropriate if the distribution of those species is already being limited by access.

22.62. Increased housing levels and development, coupled with increased awareness of access rights may result in very gradual change in access levels across sites (Liley et al., 2006b;Sharp et al., 2008). Recognising key habitats and features within sites, and monitoring their occurrence and condition over time is likely to be important.

22.63. Key features within sites (Kirby, 1992;Key, 2000;Symes and Day, 2003;Miles, 2006) include unshaded areas with a sunny aspect, ideally open to the south, free draining and sheltered from the wind. Around 2–5% coverage, potentially up to 15% in some, is thought to be about right amount of bare ground within sites (Key, 2000).

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

22.64. No new information.

Related Concerns

22.65. Access infrastructure such as boardwalks may result in the loss of areas of early successional habitats otherwise maintained through trampling. Path surfacing and drainage can damage important invertebrate habitat, for example freshwater seepages and flushes.

22.66. There is considerable material in the original guidance on the barrier effect of paths. New material includes discussion on the ecological significance of track surfacing (Kirby, 2004), In general terms the conversion of an unsurfaced path to a surfaced path tends to be highly damaging to the invertebrate interest, both in terms of a barrier effect, but also in removing potential nesting and foraging sites for species associated with bare ground. Where surfacing is required due to health and safety considerations or other reasons then aggregate is preferable to tarmac and the choice of aggregate should be appropriate to the site geology.

Opportunities Associated with a Statutory Right of Access

22.67. On larger sites or larger areas of habitat access can present some benefits in providing habitat heterogeneity and maintaining specialist microhabitats for invertebrates in particular.

22.68. Bare ground and early successional vegetation is an important habitat for a great number of rare or scarce invertebrates (Key, 2000). For example, some of the most important features for invertebrates on lowland heath are bare or sparsely vegetated patches of ground (Kirby, 2001), often associated with paths. Compacted bare ground is used for nesting by some solitary bees; bare ground in otherwise densely vegetated sites can be of great value as a basking site for flying invertebrates; the ruderal vegetation of the fringes may be of interest in its own right, and may serve as a significant food source for a number of invertebrates (Kirby, 2004). In the absence of specific management for this resource access by people or vehicles can maintain these habitats. There are sites in the UK supporting nationally important invertebrate faunas where suitable habitat (open conditions) are maintained only by unofficial motorbike activities (Key, 2000); similar examples exist for plants and are discussed in the plants chapter (chapter 23).

22.69. Similar benefits have been noted for some aquatic species, particularly those requiring early-successional habitats or befitting from micro-habitat features such as water-filled wheel ruts. IIn the chalk quarries of Bedfordshire, the activities of four-wheel-drive vehicles and motor-bike scrambling have prevented the encroachment of vegetation, thereby maintaining suitable seepages habitats for scarce blue-tailed damselfly *Ischnura pumilio* (Cham, 1996).

22.70. The introduction of new access routes to degraded sites can offer an opportunity for wildlife gain. Intensive agricultural management of cliff top land has been identified as a main threat to the ecological interest of coastal cliffs (Whitehouse, 2007); restoring suitable semi-natural cliff-top habitat can provide habitat resources for invertebrates inhabiting cliffs and coastal slopes on both hard and soft coasts. Such resources include additional habitat and foraging areas such as nectar and pollen sources, and are of particular importance where wildflower resources are limited on the cliff face or slope. Improved coastal access provides a considerable opportunity to address this issue through the establishment of wide buffer strips of coastal grassland in conjunction with enhancements to cliff top access (Whitehouse, 2007;Howe et al., 2008a).

23. HIGHER PLANTS, BRYOPHYTES, LICHENS AND FUNGI

Summary

- Research published since 2001 confirms that the main threats of open access to higher plants, bryophytes, lichens and fungi remain trampling, erosion, soil compaction and eutrophication.

- In terms of trampling of vascular plants, recent research is summarised on the impacts in woodlands, lowland heathland, calcareous grasslands and on cliff faces. The impact of resurfacing trackways is discussed, with reference to Wales and Cornwall. The varying susceptibility of particular species is noted.

- Case studies are given of the impact of trampling of bryophytes on the edge of reservoirs, in urban forests, on cliff faces and other habitats. For lichen, recent trampling studies cover heathland, shingle, sand dunes and cliff faces. Little new information is available on fungi.

- Recent research also stresses the importance of bare ground and earlier successional habitats for certain species of plants, particularly in calcareous grasslands and lowland heathlands. Examples are given of where a certain level of access benefits particular species. Against this, caution is expressed that disturbance also benefits certain exotic species, and that excess levels of disturbance generally act to the detriment of most plants.

- Horse riding and cycling have not dissimilar impacts on plants, both directly and indirectly. In terms of direct effects, both activities: trample vegetative cover, alter plant species composition damage trees and expose roots. Horses also defoliate plants through grazing. In terms of indirect impacts, both higher rights activities potentially: erode, compact and churn soil and soil particles; reduce water infiltration rates and increase surface run-off; increase trail width and stimulate creation of multiple trails; and spread plant disease. Horses also defecate on trails, causing local nutrient enrichment.

- Management considerations resulting from recent research are summarised for a variety of species and habitats, including woodlands, sand dunes and cliff faces.

Accessibility of Sites Supporting Particular Plant Interests

23.1. Enhanced coastal access will increase the extent of botanical features that may be effected by public access.

General Vulnerability of Sites with Higher or Lower Plant Interests to Direct Impacts arising from Access

23.2. The key points summarised in the original guidance (chapter 16.3) remain pertinent. The main threats of open access remain trampling, erosion, compaction and eutrophication. We cover most new relevant information for this chapter in the respective habitat chapters, but summarise key elements or species-specific issues here. We note that a large proportion of the new research relates to countries other than the UK, but may well have implications for UK management considerations where the same or similar species or genera occur in England.

23.3. We concur with the assessment of the original guidance (see para 16.3.1) that there is a good number of species that thrive in disturbed conditions; examples of nine such disturbance-dependent species are provided in Table 9 below. In addition, a comparison of calcareous and mesotrophic grasslands on Salisbury Plain found that perennial forb species, particularly hemicryptophytes[5], occurred at higher frequencies in swards disturbed 50 years ago than in undisturbed swards (Hirst et al., 2005).

23.4. Bare ground and early successional habitats are particularly important on lowland heathlands ecosystem. Some kind of physical disturbance is usually required to create these bare ground habitats, and hence a certain level of physical disturbance can be beneficial, particularly for pioneer and short-lived species (Lake et al., 2001;Piessens et al., 2008). Indeed, many plants are only associated with such habitats: slender centaury *Cicendia filiformis* and coral necklace *Illecebrum verticillatum* are associated with wet hollows, even vehicle ruts and hoof prints, whereas mossy stonecrop *Crassula tillae* is associated with bare, sandy soil (Lake et al., 2001).

23.5. At two English sites (Sonning chalk pit, Oxon, and Banstead Downs, Surrey), mountain bike disturbance has benefited broad-leaved cudweed *Filago pyramidata*, this UK BAP species growing in areas dug for jumps as well as eroded by tyres (N. Hutchinson/Plantlife pers. comm.). At Ranmore Common in Surrey, the ground pine *Ajuga chamaepitys* population is dependent on motorbike scrambling to create bare soil; while motorbike activity remains high, the species thrives (N. Hutchinson/Plantlife pers. comm.). Another example relates to lichen-dominated vegetation on coastal grey dune heath (in Denmark, but similar habitats exist in eastern Britain), where tourist pathways provide open space for pioneer mosses and lichens to colonise, hair-grass *Corynephorus* species being adapted to dispersal by fragments, spores or seeds, although regeneration may take years (Christensen and Johnsen, 2001).

23.6. As stated in the original guidance (see para 16.3.2), a carefully planned and managed access regime may thus assist particular species. What remains unclear, however, and would make a useful topic for future research, is where the optimum point in the disturbance gradient lies (i.e. where access levels are sufficient to be beneficial but not so high as to be damaging). Experience with broad-leaved cudweed at Halnaker chalk pit in West Sussex illustrates the problem. Motorcycle scrambling here maintains bare ground to the benefit of the species, but heavy usage compacts the soil, to the detriment of the plant (N. Hutchinson/Plantlife pers. comm.).

23.7. Site managers should be aware that disturbance is thought to benefit exotic plant species. Research in Canadian grasslands demonstrates a significant positive relationship between the species richness and diversity of exotic plant species and the magnitude of the disturbance (Vujnovic et al., 2002). A similar relationship was found on some islands in the US, although the effect was less pronounced in the harsh saline conditions of sand dunes, suggesting that human disturbance does little to foster alien invasions in environments where the stress levels are not mitigated, (Rodgers and Parker, 2003). In

[5] Plants with perennial buds at the surface of the ground where they are protected by soil and leaves e.g. grasses etc. and rosette plants

Belgian woodlands, most of the species that grow well on heavily compacted forest soil (e.g. following trampling) are non-forest species (Godefroid and Koedam, 2004b). In Finnish forests, trampling provided opportunities for non-sylvan species to establish in previously unbroken forest vegetation. Urban forest edges were characterised by grasses better adapted to sunny, warm and dry conditions, which replaced more sensitive forest species such as dwarf shrubs and mosses (Hamberg et al., 2008). Disturbance may also benefit "undesirable" native species, for example, artificial trampling on wet heathland was found to greatly increase the number of willow *Salix* species seedlings germinating (Lake, 2002).

23.8. As the original guidance suggests (see para 16.3.3), there are some plants for which unmanaged public access could be damaging. This is particularly true for plants restricted to physically fragile habitats. One example is valley mires in lowland heathlands, which contain sphagnum moss communities and species such as bog orchid *Hammarbya paludosa*, which are known to be vulnerable to trampling (Lake et al., 2001). For vulnerable vegetation on montane cliff faces, see the research on rock climbing synthesised in the *Mountains and moor* chapter.

Trampling and Erosion

23.9. We follow the format of the original guidance (see para 16.3.4), where general reviews of the sensitivity of main habitat component species are given in the chapters devoted to separate habitats.

Higher Plants

23.10. Disturbance issues (including habitat loss/degradation from development) has been identified as threat for a 24 BAP priority plants. Lack of disturbance is an issue for nine disturbance-dependent species associated with bare ground or early successional habitats.

Table 10: BAP priority plant species (from 2005) where disturbance or housing issues identified as a current or emerging threat. Data are from 2005 BAP reporting round. Coastal erosion and habitat loss / degradation from development are included in the table as these can be access related.

	Erosion (coastal)	Habitat loss / degradation		Lack of disturbance	Human disturbance		
		From coastal development	From housing infrastructure		Interference / displacement	Other recreation / tourism	Trampling (physical damage)
a Red Alga *Anotrichium barbatum*		✓					
Creeping Marshwort			✓				
Tower Mustard			✓				
Wild Asparagus	✓						✓
Greater Copperwort			✓				
Convergent Stonewort						✓	
Mountain Scurvy-grass						✓	
Stinking Hawk`s-Beard				✓			
Lady`s Slipper Orchid					✓		
Western Ramping-fumitory				✓			
Dune Gentian		✓		✓			
Pygmy Rush				✓			
Juniper				✓			
Floating Water Plantain						✓	
Pennyroyal			✓	✓			
Starry Stonewort						✓	
Grass-wrack Pondweed						✓	
Shetland Pondweed			✓				
Three-lobed Water-crowfoot				✓			
Greater Water Parsnip				✓			
Derbyshire Feather-moss					✓		
Cotswold Pennycress				✓			
Tassel Stonewort					✓		
Killarney Fern					✓		

23.11. Overall, herbaceous plants tend to have a higher resilience to trampling than bryophytes, lichen or fungi (Whinam and Chilcott, 2002), perhaps because they take up nutrients via their roots (Hamberg et al., 2008).

23.12. Rates of damage to British woodland ground flora (homogeneous stands of bluebell *Hyacinthoides non-scripta*, bracken *Pteridium aquilinum* and bramble *Rubus fruticosusi)* were most rapid at the initial stages of trampling (Littlemore and Barker, 2001). The ability of ground flora to tolerate impacts was more a function of an ability to recover from trampling, rather than to resist. By virtue of its rosette growth form, the most resistant stand type was *Hyacinthoides*. Least resistant was *Pteridium*, but both *Pteridium* and *Rubus* were able to recover well from heavy levels of trampling by the following year. Trampling had the most profound impact on the ability of bluebells to produce seeds, and even two years after the cessation of impact, samples that had received one season of 500 passes had still not produced any seed-bearing scapes. The carrying capacity of woodlands in terms of visitor numbers was lower than previously thought, being only 35 people in stands dominated by bluebells, rising to 450 and 500 people in woodlands dominated by *Rubus* and *Pteridium* stands respectively (Littlemore and Barker, 2001).

23.13. An experimental assessment of the impact of recreational activity in a Swiss beech *Fagus* forest (Amrein et al., 2005) revealed that recreational use of forests can significantly affect soil characteristics, understorey vegetation and the soil seed bank. Impacts on soil characteristics and the soil seed bank have already been discussed in the Woodlands chapter (see paras 8.6 - 8.7).

23.14. The understorey vegetation of beech forests is a vegetation type particularly vulnerable to trampling. Disturbed areas had: considerably lower total plant species richness; significantly lower species densities in the herb and shrub layer; reduced height and cover of herb layer (the latter two characteristics were both correlated with increasing soil compaction). However, species richness in the tree layer did not differ (Amrein et al., 2005).

23.15. In Snowdonia National Park, Wales, the recent resurfacing of a cycle path has had an adverse impact on narrow-leaved helleborines *Cephalanthera longifolia*. Resurfacing has resulted in an increase in use by cyclists and walkers, attracted by the improved path conditions, and a proportion of visitors have ventured off-path where they have trampled the orchids (N. Hutchinson/Plantlife pers. comm.).

23.16. Resurfacing of trackways on the Lizard Peninsula, Cornwall, has inadvertently led to local extinctions of ephemeral annuals such as pygmy rush *Juncus pygmaeus*, pillwort *Pilularia globulifera* and three-lobed water-crowfoot *Ranunculus tripartitus*. The resurfacing was a response to the perceived needs of walkers and horses which derived from the opening up of land to recreational access, which itself resulted from the changing economics of farming meaning that keeping grazing animals was no longer profitable (N. Hutchinson/Plantlife pers. comm.).

23.17. On heathland, different heather species are susceptible to different levels of trampling. On English heaths, heather *Calluna* heather has been found to be more damaged by trampling than purple moor-grass *Molinia caerulea* (Lake et al., 2001). The highly resilient Dorset heath *Erica ciliaris* is more resistant to trampling in summer than winter (Gallet and Roze, 2001) and more tolerant in wet conditions than dry (Gallet and Roze, 2002). In summer bell heather *Erica cinerea* is more sensitive to trampling in wet weather than dry (Gallet and Roze, 2001). Heather species were more sensitive than the rest of the plant cover (Gallet and Roze, 2001).

23.18. Repeated trampling affects the recovery rate of different heather species in different ways (Gallet et al., 2004). The impact on Dorset heath was the same at any trampling rate between one and five passes, whereas for bell heather and western gorse *Ulex gallii*, trampling was slightly less damaging when applied once than five times. Dorset heath is thought to have a lower resistance and higher recovery capacity.

23.19. An assessment of the impact of trampling on a heathland community in Belgium suggested that graminoid (purple moor-grass, wavy hair-grass *Deschampsia flexuosa*) and dwarf-shrub species (bilberry *Vaccinium myrtillus,* heather*,* cross-leaved heath *Erica tetralix*) were relatively resistant (Roovers et al., 2004).

23.20. An assessment of the effects of management and adjacent forest on Belgian heathland (Piessens et al., 2008) notes that management type and intensity profoundly affect vegetation structure, particularly of the dominant dwarf shrub heather.

23.21. In English calcareous grasslands, mountain bike disturbance at two sites has created bare ground to the benefit of broad-leaved cudweed *Filago pyramidata* (N. Hutchinson/Plantlife pers. comm.).

23.22. Pristine cliff faces in Canada have nearly double the vascular plant richness of cliff faces subject to rock climbing (Kuntz and Larson, 2006a). Another study found that the density, percent cover, species richness, and species diversity of vascular plants were lower on climbed outcrops than on unclimbed outcrops (McMillan and Larson, 2002). A study in Switzerland found that vascular plant cover and species density was significantly reduced at the base and on the face of cliffs subject to sport climbing. Climbing also significantly altered plant composition and reduced the densities of specialised rock species (Müller et al., 2004).

Bryophytes

23.23. Two species of threatened bryophyte (violet crystalwort *Riccia huebeneriana* and beaked beardless-moss *Weissia orstellata*) occur on the acidic mud shores of Dartmoor reservoirs (Plantlife, 2006) and are susceptible to shore-based anthropgenic activities.

23.24. In Finnish urban forests, the effects of off-path trampling were most clearly visible among mosses, while even on-path trampling changed species composition and density for 8 m off-path, probably because of micro-climatic changes (Hamberg et al., 2008). This suggests that bryophytes may be particularly affected by open access. Particularly vulnerable species identified were *Brachythecium* spp., *Pleurozium schreberi*, *Hylocomium splendens*, *Dicranum polysetum* and *Vaccinium myrtillus*. The recovery of dwarf shrubs such as the latter species is very slow. In contrast, rowan *Sorbus aucuparia* appeared to benefit from trampling, and bryophytes that grow in low, thick tufts, such as *Pohlia nutans*, may be more resistant to trampling than the longer, looser shoots of *Brachythecium* species (Hamberg et al., 2008).

23.25. Species richness of bryophytes on cliff faces in Canada subject to rock climbing was a third lower than pristine faces (Kuntz and Larson, 2006a). Another study found that the frequency and richness of bryophyte species were significantly lower in climbed areas (McMillan and Larson, 2002).

23.26. A study in North America assessed the dynamics of epiphytic bryophyte communities on bigleaf maple trees *Acer macrophyllum* following experimental disturbance (Cobb et al., 2001). Following their removal, 8% of the exposed area was recolonised by bryophytes one year after clearing and 27% after three years. Disturbance appeared to reduce bryophyte diversity at this successional stage, remaining low after one year and still not having recovered after three years. Disturbance level was thought to probably significantly affect the time needed to recolonise disturbed branch substrates (Cobb et al., 2001).

23.27. A study of nutrient enrichment on high Arctic heaths found that an addition of 10 kg of nitrogen per hectare per year increased the proportion of physiologically active bryophyte shoots, and decreased their nitrate assimilation capacity. Phosphorus had greater effects. Individual bryophyte species displayed contrasting responses to fertilization, suggesting that they should not be grouped as a single functional type (Gordon, 2001).

23.28. An assessment of the effects of management and adjacent forest on the heathland bryophyte layer in Belgium (Piessens et al., 2008) recalls previous research that the bryophyte community composition is strongly influenced by management type. Effects of management are usually indirect, as it primarily affects the structure and biomass of the overgrowing herb and shrub layer, the key factor controlling cryptogam flora being competition from higher plants.

23.29. Human disturbance and air pollution seem to be the major factors limiting the colonisation of bryophytes on the Boston Harbour Islands in the US (Lagreca et al., 2005).

Fungi

23.30. In 2005 lead partners involved in the UK BAP were asked to report on their species and habitats (see Defra, 2006 for details). Devil's bolete *Boletus satanas* was the only priority action species (at that time) for which human disturbance (trampling and/or physical damage) was identified as a current or emerging threat. For the pink waxcap *Hygrocybe calyptriformis* habitat loss and/or degradation as a result of housing infrastructure is identified as a threat.

Lichens

23.31. The Breck heaths (Norfolk/Suffolk) are characterised by a high cover of lichen species, including species of conservation concern. Some of these are likely to be vulnerable to trampling, particularly in dry conditions, when brittle (Liley et al., 2002). Ground disturbance in winter, when ground is waterlogged and can be churned up is also damaging for terricolous species (e.g. Gilbert, 2002).

23.32. On shingle, communities with abundant lichens are susceptible to trampling, again particularly during dry weather. A single pass may be sufficient to cause irreparable damage (Doody and Randall, 2003).

23.33. Outside the UK, lichen species richness was little different on Canadian cliff faces subject to rock climbing pressure and pristine faces (Kuntz and Larson, 2006a). In another study there, the frequency of lichens was the same on climbed and unclimbed cliffs, but species richness was significantly lower in climbed areas, and community composition differed between climbed and unclimbed areas (McMillan and Larson, 2002).

23.34. In an experimental study of trampling effects on Belgian sand dune vegetation, the resistance and resilience of three typical plant communities were compared (Lemauviel and Roze, 2003); details are given in the Dunes chapter (see chapter 14, para 14.15).

23.35. An assessment of the threats to lichen-rich, grey hair-grass *Corynephorus canescens*-dominated grey dune vegetation on acidic sand in Denmark (Christensen and Johnsen, 2001) is relevant to the UK as similar habitat occurs within the UK (both at coastal and inland sites). The Danish site is subject to heavy seasonal tourism and human trampling has a pronounced negative impact. Moderate trampling in the grey dune vegetation results in a reduction in species number and vegetation cover; a community of colonizers or early succession species now predominates. In the most trampled parts, only a few (or even no) species remain, and the substrate is worn down to bare sand. Frequent trampling means that later succession stages become an increasingly rare element of the vegetation. Moreover, the invasion of exotics (Swiss mountain pine *Pinus mugo*, Japanese rose *Rosa rugosa* and heath star-moss *Campylopus introflexus*) and atmospheric nutrient enrichment also threaten native lichens at the Danish site; given the evidence and inferences of anthropogenic exacerbation of both processes, site managers in the UK should take note of such potential impacts of open access.

23.36. A study of nutrient enrichment on high Arctic heaths found that applications of any level of nitrogen decreased lichen cover (Gordon, 2001).

23.37. Human disturbance and air pollution seem to be the major factors limiting the colonisation of lichens on the Boston Harbour Islands in the US (Lagreca et al., 2005).

Spreading species

23.38. Recent information on spreading species all comes from outside the UK, but may still have relevance. Rock climbers in Canada have been found to spread non-native plant species to cliff faces (McMillan and Larson, 2002). People and dogs visiting the forest can carry non-native seeds. In frequently visited areas there is an increased probability that non-native plants can establish. In Swiss beech forests, disturbed areas had a larger proportion of seeds (of trampling-tolerant species) dispersed by animals and humans (Amrein et al., 2005). If these findings were replicated in the UK, it is likely that such dispersal of non-native species would be increased by open access.

Eutrophication of Soils

23.39. Sites used for dog walking and horse riding may suffer from localised nutrient enrichment as a result of defecation. Sites closest to high numbers of dog walkers (e.g. those on urban fringes) are potentially particularly susceptible. New material published since the original guidance are reviews (Taylor et al., 2005;Taylor et al., 2006) which give information on dog fouling behaviour, chemical composition of faeces and the impacts to vegetation. There are also a number of studies that explore the behaviour and attitudes of dog walkers (Barnard, 2003;Edwards and Knight, 2006;Liley et al., 2006d;Liley et al., 2006g). Further details are covered within the grassland chapter (see chapter 7, paras 7.10 – 7.11). The impact of nutrient enrichment from dogs and horses remains a fertile area for future research.

Types of Site with Particular Vulnerability to Access Related Issues

23.40. Recent research does not substantively change the assessment in the original guidance (chapter 16.4), although we would explicitly add bogs, for example small lowland bogs in heathlands, as a type of site that is particularly vulnerable to access related issues (Lake et al., 2001). Complementary information on the impact of rock climbing on vulnerable cliff face vegetation, particularly bryophytes and lichens, is given in the *Mountain and moor* chapter.

23.41. We also reiterate the importance of disturbance for certain native species, for example some hemicryptophytes in calcareous and mesotrophic grasslands (Hirst et al., 2005), and species such as slender centaury, mossy stonecrop, coral necklace and pygmy rush on lowland heathlands (Lake et al., 2001;Liley et al., 2002). A carefully planned and managed access regime may thus assist particular species.

Associated Interests

23.42. No new information.

Implications of research

23.43. That damage to ground flora of a British woodland is at its most rapid when use levels are low has important implications for site management (Littlemore, 2001;Littlemore and Barker, 2001) is discussed in the Woodland chapter, as are management implications from research in Swiss beech woodland (Amrein et al., 2005), Belgian forests (Roovers et al., 2004;Roovers et al., 2005b) and Finnish urban forest fragments (Hamberg et al., 2008).

23.44. In Snowdonia National Park, Wales, the recent resurfacing of a cycle path has resulted in increasing levels of walkers and cyclists, a proportion of whom have ventured off-path and trampled narrow-leaved helleborines. PlantLife is now working with the national park authorities to prevent further trampling through fencing (N. Hutchinson/Plantlife pers. comm.).

23.45. In the light of local extinctions of ephemeral annuals such as pygmy rush, pillwort and three-lobed water-crowfoot on the Lizard Peninsula, Cornwall, Plantlife highlighted several considerations for site managers seeking to counter the adverse impact of trackway resurfacing (N. Hutchinson/Plantlife pers. comm.). It was suggested that all species benefit from two ‘levels’ of management: holistic heathland grazing through which the trackways run, and micromanagement of the trackways themselves, to create the open conditions favoured by these pioneer species. Grazing is essential for low growing perennial damp trackway grassland species, whilst light rutting creates open ground into which these species can spread vegetatively. For annual species, all benefit from exposure of the mineral soils underlying the trackway system, whilst the build-up of organic material (e.g. leaf litter) is inimical to their continued survival. It was proposed that periods of heavy cart track usage should take place when the rarer species are dormant. Thus for the aquatic winter annual species trackways should be heavily disturbed in summer or early autumn, but relaxed thereafter as the species germinate and grow. Conversely, if a trackway system is only known to support spring-germinating species, the winter use of trackways should be compatible with their survival (N. Hutchinson/Plantlife pers. comm.).

Circumstances in which Statutory Exclusion or Restriction of Access should be considered

23.46. The original guidance (see para 16.6.4) suggests that statutory exclusions or restrictions might be necessary where special plants grow on exceptionally fragile habitats such as cliff ledges used by rock-climbers. While not dissenting from this, we note that recent evidence is rather conflicting in this respect, and we direct readers towards the potential management considerations to offset the impact of rock climbing on cliff face vegetation contained in the *Mountain and moor* chapter. We also draw attention to the management recommendations for chalk grasslands, based on work on Salisbury Plain, in the *Lowland grasslands* chapter.

23.47. A recent assessment of the threats to lichen-rich, grey hair-grass - dominated grey dune vegetation on acidic sand in Denmark (Christensen and Johnsen, 2001) notes the adverse impact of moderate trampling but cautions that selective access can be beneficial for some pioneer mosses and lichens. In conclusion the researchers suggest the need for careful management of tourists, but do not propose any outright exclusions.

Related Concerns

23.48. Recent research does not substantively change the detailed assessment provided in the original guidance (chapter 16.7.9). However, we echo the importance of careful management of sites that have grazing herbivores and draw attention to recent experience and recommendations on this issue (Lake, 2001;Lake et al., 2001;Lake, 2002;Lake and Underhill-Day, 2004).

Opportunities Associated with a Statutory Right of Access

23.49. No new information.

24. GEOLOGICAL SITES

Summary

- There is very little new information to add to the assessment provided in the original guidance under "Earth Heritage". We have covered new research on geological features such as caves, cliffs and coastal features in the *Mammals* (for caves housing bat colonies), *Mountains and* moor (for rock climbing on cliff faces), and *Coastal habitats* chapters, respectively.

Accessibility of Sites with Geological Interests

24.1. No new information to add to the assessment provided in the original guidance (chapter 17.2).

General Vulnerability of Geological Sites to Direct Impacts arising from Access

24.2. The original guidance (chapter 17.3) lamented that little research was available on the effects of access on Geological sites, and this remains true today.

Types of Site with Particular Vulnerability to Access Related Issues

24.3. There is no new information to add to this chapter. Geological interests include natural features for which post-2001 information is provided in the appropriate chapter, e.g. coastal foreshore and cliff exposures in *Coastal habitats*.

Associated Interests

24.4. As noted in the original guidance (chapter 17.5), there is a strong cross-over between Geology and nature conservation interests. Where relevant, new information is included in the relevant faunal chapter. Caves are a good example, as this type of Geological site attracting general tourists and specialized cavers. As well as disrupting physical features, human activity in caves can affect bat colonies adversely, and new research on impacts and mitigation solutions is discussed in the *Mammals* chapter.

24.5. Clear guidance on fossil collecting have been published (Larwood and Edmonds, 2007)and are available online. National guidance is provided by the UK fossils network[6] and specific guidance for the Dorset Coast / Jurassic Coast world heritage site is also available[7].

[6] http://www.ukfossils.co.uk/national_collecting_code.htm

[7] http://www.jurassiccoast.com/downloads/uploads/full_fossil_collecting_code.pdf

Circumstances in which Statutory Exclusion or Restriction of Access should be Considered

24.6. For suggestions to complement the material in the original guidance (chapter 17.6), see the equivalent chapter in the chapters on Mammals (for caves housing bat colonies), Mountains and moor (for rock climbing on cliff faces), Open water (for river and stream features) and Coastal habitats. Otherwise there is no new information that merits changing the 2001 assessment.

Related Concerns

24.7. No new information to add.

Opportunities Associated with a Statutory Right of Access

24.8. No new information to add.

25. FURTHER RESEARCH

The following areas are current gaps in the evidence base and directions for further work.

General

25.1. There is a still a need to develop our understanding of the links between housing and access levels to different kinds of sites. In particular there is a need to understand how increased numbers of houses in a given area may result in changes in access levels and patterns of access on surrounding sites. There is pressure to find space for new housing in much of southern England, and such work would be relevant to a range of habitats, including coastal sites (shingle, sand dunes) and heathland.

Horse riding and cycling:

25.2. Given the lack of research in the UK, there is a need for research on UK sites, habitats and species. Both experimental and observational work should seek to compare different recreational intensities and levels of impact. Heathlands in southern England could be suitable study locations.

25.3. It is crucial to understand the consequence of track damage for the nature conservation interest of sites. Work to explore the effect of soil compaction, greater erosion, path widening and churning of ground on key species would be useful. A series of studies on different habitats is recommended. Key species would include invertebrates such as tiger beetles, aculeate Hymenoptera; plants associated with trackways and sand lizards.

25.4. We recommend work to understand the area of bare ground habitats within a range of sites, the range of bare ground habitats present and the proportion of those habitats that are used by cyclists and horse riders. This work should be straightforward to collate using aerial photographs within a GIS. Biological data (species presence / absence on sites / tracks / patches) could then also be included, and potentially levels of use by people. Such a study could therefore combine access monitoring and biological data to address the extent to which horse riding and cycling are having an impact on the nature conservation interest of the sites

25.5. Given the lack of work on the impacts of disturbance from cyclists and horse riders, there is scope for a study to compare how birds respond to different types of activity. Such a study could take various forms. The flush response (time off nest, distance flushed) could be recorded for a ground nesting species. The different activities would probably need to be experimentally controlled. Experimentally disturbing feeding birds on a mudflat or similar could also be conducted. Ideally any such study would aim to link the behavioural responses to population effects.

25.6. We advocate the development of visitor models (either spatial pressure models or agent-based modelling) to include cycling and horse riding, and suggest that these would then provide the potential to predict consequences of different access management measures on nature conservation interest.

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Lowland Heathland

25.7. There is scope to refine existing-site visitor models (either spatial pressure models or agent-based modelling) with further visitor monitoring both within and between sites, to determine spatially where within sites and to what magnitude visitor pressure exists. Such models could explore issues relating to trampling on different substrates/plant communities/erosion/slopes/by visitor types as a way of determining the upper and lower thresholds for different plants/ communities.

25.8. Models could also be used to see the impact of site-specific targeted management, e.g. path closures, education, path rotation, dog-walking routes, CROW restrictions etc.

25.9. The extent of dog fouling within sites and the long term implications on the nature conservation interest of sites is a real gap. Research should address:

- Nutrient levels (how far into sites enrichment occurs and whether there is a gradient or discrete boundaries);

- Implications for different plant communities (whether tipping points exist and how long communities take to recover);

- Whether there is a quick way of assessing nutrient enrichment by changes in plant community

25.10. There is the potential to combine soil sampling with existing visitor monitoring to link soil nutrient levels to the number of dogs. Any research should also address different strategies for managing nutrient enrichment from dogs, e.g. education, wardening, threat of fines, no pick-up areas, and the potential move access points away from the most nutrient sensitive communities.

25.11. Bare ground is a key habitat of interest and there is scope to explore changes in path networks over time (e.g. through aerial photographs), changes in the extent of bare ground, extent of bare ground habitats away from footpath networks and the extent to which providing and maintaining alternative bare ground is preferable to visitor management.

Coastal Habitats

25.12. There is a need to understand how access can be achieved in dynamic coastal environments where shingle ridges and sea walls may be prone to breaching in the near future. Such work should address how access schemes could adapt as the coast changes and how to ensure that access can adapt alongside the conservation interest.

25.13. Other research is needed on how access and restoration of habitats can interact to achieve enhanced access and environmental enhancement).

25.14. More work is needed on how trampling affects sediment levels in saltmarsh.

25.15. The impact of dog faeces for shingle and dune habitats warrants further work, which could be combined with the recommended work for heathlands outlined above.

25.16. More work is needed to determine how traditional grazing practices can be maintained on coastal habitats in the face of increasing public access.

Birds

25.17. Four recent reviews have identified priorities for future research on bird conservation and access to the countryside in England (Liley, 2001;Langston et al., 2007a;Sutherland, 2007;Liley, 2007).

25.18. In 2001, the priority was to determine impacts of access to birds of mountain, moor, heath and down, and to commons (Liley, 2007). Some of the work consequently prioritised by Liley (2001) has now been carried out, and for most key species there is now a body of research on disturbance and its impacts (Langston et al., 2007a). It is apparent that the research context is now very different, the principal gaps in our understanding now concerning people (Langston et al., 2007a), with a consequent need to focus on the area where social and ornithological approaches meet (Liley, 2007).

25.19. Recommended work broadly falls into three categories: work on access patterns/behaviour; access management studies; and ornithological work (Liley, 2007).

25.20. Understanding what determines patterns of human behaviour is clearly key (Sutherland, 2007). The impacts of enhanced coastal access are important to understand, including studies of visitor behaviour and modelling of the impact on breeding and wintering birds of various access scenarios (Liley, 2007). Given that access and nature conservation are no longer perceived to be in irreconcilable conflict (Liley, 2007), there is benefit in further examining the positive consequences of access to the countryside (Sutherland, 2007).

25.21. Research should seek to inform where to target limited resources to most benefit birds and minimize unnecessary restrictions to public access. It follows that predictive modelling would allow identification of areas of high visitor pressure that coincide with key sites for sensitive species (Langston et al., 2007a; Liley, 2007).

25.22. It is important to assess the efficacy of various access management tools currently deployed or recommended for deployment, to understand how they influence where people go (Liley, 2007) or otherwise reduce human impact (Sutherland, 2007). The particular impact of a wide range of recreational activities (e.g. climbing, coasteering) would merit study, and there is a need to continue to monitor future changes in recreational access to the countryside, particularly where there is potential for impacts on vulnerable species and habitats (Langston et al., 2007a).

25.23. These studies on human behaviour should be combined with ornithological research that focuses on the impact of disturbance on bird physiology, fitness and energy costs, ecology and populations, perhaps combined with examinations of the impact of dogs and other predators, or the effect of habituation (Schummer and Eddleman, 2003;Gill, 2007;Gilroy and Sutherland, 2007;Sutherland, 2007;Liley, 2007). Research enabling parallels to be drawn between different species would enable site managers to understand the likely sensitivity of a particular species to a particular activity (Sutherland, 2007). It would also be useful to determine the significance of disturbance-derived ecological traps, areas that species select but are actually population sinks (Sutherland, 2007).

Reptiles and Amphibians

25.24. It would be useful to determine the importance of heathland tracks and paths in providing habitat for sand lizards. It would be worthwhile to compare a range of sites and identify what proportion of bare ground (suitable for sand lizards) within each site occurs on footpaths and access routes. This work could be developed further to address impacts of trampling, use of different paths and potentially therefore start to determine whether trampling can have population impacts for sand lizards.

Invertebrates

25.25. There is a general lack of understanding on the impacts of access in creating and maintaining critical bare ground habitats within sites, and this is a clear area for further work. It would be relatively straightforward to assess the extent of bare ground habitats within a range of sites and then determine what proportion of the total area is actually on footpaths or tracks. Such work could be combined with biological data (species occurrence) and visitor data (visitor flows, types of access).

25.26. There is also scope for further work on the impacts of resurfacing paths.

Plants

25.27. Further research is needed into the role of public access in maintaining bare ground and early successional vegetation.

26. Glossary and Abbreviations

26.1. We include here a glossary of technical terms, acronyms and abbreviations used within the report.

Glossary

All terrain vehicle (ATV): Vehicle that travels on low pressure tires, with a seat that is straddled by the operator, and with handlebars for steering control. Commonly known as a quadbike.

Anthropogenic: Anthropogenic effects, processes, objects, or materials are those that are derived from human activities, as opposed to those occurring in natural environments without human influences.

Blanket bog: Blanket bog or Blanket Mire is an area of peatland, forming where there is a climate of high rainfall and a low level of evapotranspiration, allowing peat to develop not only in wet hollows but over large expanses of undulating ground. The blanketing of the ground with a variable depth of peat gives the habitat type its name.

Broadcast spawners: Species which release eggs and sperm into the water column for external fertilization and development.

Canids: Any of various widely distributed carnivorous mammals of the family Canidae, including foxes, wolves, dogs, jackals, and coyotes.

Carabid: Any of a large family (Carabidae) of chiefly black beetles that often inhabit the spaces under stones, logs, or piles of debris and feed on other insects. Also called ground beetle

Collembolan: Belonging or pertaining to the insect order Collembola, comprising the springtails.

Corvids: Corvidae - a family of oscine passerine birds that contains the crows, ravens, rooks, jackdaws, jays, magpies, and choughs. Collectively its members are called corvids.

Cryptogam: Plants (in the wide sense of the word) which reproduce by spores

Demographic: A statistic characterizing human populations (or segments of human populations broken down by age or sex or income etc.)

Density-dependent: Effects whose intensity changes with increasing population density.

Epilimnetic: (in certain lakes) the layer of water above the thermocline (a layer of water in an ocean or certain lakes, where the temperature gradient is greater than that of the warmer layer above and the colder layer below).

Eutrophication: An increase in chemical nutrients (typically compounds containing nitrogen or phosphorus) in an ecosystem. It may occur on land or in water. The term is however often used to mean the resultant increase in the ecosystem's primary productivity (excessive plant growth and decay), and further effects including lack of oxygen and severe reductions in water quality, fish, and other animal populations

Exclusion: A CRoW specific term relating to areas within open access which are closed to access for a specific period of time. See also “restriction”.

Fitness: The extent to which an organism is adapted to or able to produce offspring in a particular environment

Flight initiation distance: The distance from a disturbance (e.g. a walker) at which a bird flies in response to that disturbance.

Forb: Herbaceous flowering plants that are not graminoids (grasses, sedges and rushes). The term is frequently used in vegetation ecology, especially in relation to grasslands. Forbs represent a guild of plant species with broadly similar growth form, which in ecology is often more important than taxonomic relationship

Gammarids: any member of the family Gammaridae, the largest of 80 or so families that make up the crustacean order Amphipoda.

Graminoids: Grasses (family Gramineae or Poaceae) and grasslike plants such as sedges (family Cyperaceae) and rushes (family Juncaceae).

Herptofauna: Reptiles and amphibians

Individuals-based model: A modelling approach based on using individual behaviour to predict consequences to the whole population of individuals.

Mesophilous: Charactersised by a moderate and constantly moist environment.

Mesotrophic: Mesotrophic soils are soils with a moderate inherent fertility. An indicator of soil fertility is its base status, which is expressed as a ratio relating the major nutrient cations (calcium, magnesium, potassium and sodium) found there to the soil's clay percentage

Microarthropod: A small invertebrate (< 2 mm) in the phylum Arthropoda, e.g. mites (Acari) and springtails (Collembola).

Mire: A type of wetland that occurs where the water at the ground surface is acidic (from either acid ground water or precipitation), leading to the formation of peat which is colonised by a characteristic range of vegetation communities. Also known as bog.

Niche: The position or function of an organism in a community of plants and animals

Oligochaetes: Any of various annelid worms of the class Oligochaeta, including the earthworms and a few small freshwater forms.

Oligotrophic: (of a lake) characterized by a low accumulation of dissolved nutrient salts, supporting but a sparse growth of algae and other organisms, and having a high oxygen content owing to the low organic content.

Ombrotrophic: Ombrotrophic ("cloud-fed") refers to soil or vegetation which receives all of its water and nutrients from precipitation, rather than from streams or springs.

Oospores: A fertilized female cell or zygote, especially one with thick chitinous walls, developed from a fertilized oosphere

Periphyton: The community of tiny organisms, e.g. protozoans, hydras, insect larvae, and snails, that lives on the surfaces of rooted aquatic plants

Physiological: Of or pertaining to physiology; consistent with the normal functioning of an organism

Restriction: A CRoW specific term. Access is allowed but is restricted in some way (for example to linear routes or dogs on leads only). See also "exclusion".

Terricolous: Living on or near the ground

Valley mire: A mire or bog forming in gently sloping valleys or hollows on acidic subtrates. A layer of peat fills the deepest part of the valley, and a stream may run through the surface of the mire.

Abbreviations

SNH: Scottish Natural Heritage.

CCW: Countryside Council for Wales.

CRoW: Countryside and Rights of Way.

Defra: Department for Environment, Food and Rural Affairs.

MoD: Ministry of Defence.

RSPB: Royal Society for the Protection of Birds.

SAC: Special Areas of Conservation, sites protected under the EC Habitats Directive.

SPA: Special Protection Areas, sites sites classified in accordance with the EC Directive on the Conservation of Wild Birds.

UK BAP: UK Biodiversity Action Plan.

Appendix I: “Category A” bird species”

“Category A” species are those bird species considerd to be potentially vulnerable to disturbance because of their status, abundance or behaviour. The list has been developed by Natural England staff. The selection process is summarised and the full list given below.

Selection process

1. All regularly occurring species listed on Schedule 1 of WAC were considered.

2. Additional species were added if considered vulnerable to changes in access due to conservation status, rarity, degree of aggregation, sensitivity to disturbance and degree of likely overlap between people and habitat.

3. Rare, localised and highly aggregated species are all considered vulnerable because relatively small, localised changes to access could potentially have a disproportionately greater effect on their populations. The more dispersed species on the list are of less concern as only widespread changes to access are likely to have an effect (which probably not likely away from the coast).

4. Known or likely sensitivity has been applied conservatively, generally being based on published evidence (note that sensitivity can range from behavioural observations, correlative studies or conclusive evidence of a population-level effect). It has also been applied to species which breed in colonies, which are generally very sensitive to disturbance. This is a quick assessment and would benefit from a review of disturbance studies for each species.

5. Some species have been listed because the degree of potential overlap between their main habitat(s) and areas where access levels are likely to change (or are already high) is significant. This criterion relates largely to beach-nesting waders and seabirds.

Species list

Key: **Bold** = on original category A list; *italics* = low concern; Sch 1 = WAC Schedule 1; BoCC = Birds of Conservation Concern (red and amber); BAP = BAP priority species; rare = <300 pairs in England; highly localised/aggregated = greater than 50% of population at 10 or fewer sites in England; known or likely sensitivity = at least some information to suggest high sensitivity to disturbance. Table refers to breeding birds unless otherwise specified.

	Sch 1	*BoCC*	*BAP*	*Rare*	*Highly localised/ aggregated*	*Known or likely sensitivity*	*Constrained habitat*	*Comments*
Black-necked Grebe	X	A		X	X			Wetland/open water habitats relatively inaccessible. No evidence of particular sensitivity to disturbance.
Bittern (breeding and non-breeding)	X	R	P	X	X	X		Known to be sensitive to disturbance: access adjacent to reedbeds, especially on raised banks, might displace breeding and wintering birds.
Garganey	X	A		X				Wetland/open water habitats relatively inaccessible. Relatively dispersed, although only associated with undisturbed sites.
Pintail	X	A		X	X			Wetland/open water habitats relatively inaccessible. Sensitivity to disturbance unknown.
Honey Buzzard	X	A		X	X	X?		Restricted to woodlands. Probably sensitive to disturbance. Very few breeding locations in England.
Red Kite (roosting)	X	A			X			Recently reintroduced and expanding population in England. Birds aggregate at winter roosts. No evidence of particular sensitivity to disturbance when nesting or roosting.
Marsh Harrier (reedbeds)	X	A					X	Around 60% nest in reedbeds, often very small in extent, and thus the species is vulnerable to disturbance from adjacent activities.
Hen Harrier (breeding & roosting)	X	R		X	X			Birds often use traditional, localised roosts and can aggregate (including other raptors e.g. Merlin) and require disturbance-free areas. Breeding birds very rare in England and restricted to few moorland locations.
Montagu's Harrier	X	A		X	X			Generally sporadic or occasional breeder only, majority now nesting in arable crops.
Goshawk	X			X		X		Sensitive to disturbance but relatively dispersed species.
Golden Eagle	X	A		X	X	X		Very rare breeder in England and sensitive to disturbance.

Osprey	X	A		X	X	X?		Currently only present at two (?) sites in England where access carefully controlled (?)
Merlin (roosting)	X	A			X			Birds often use traditional, localised roosts and can aggregate (including other raptors e.g. Hen Harrier)and require disturbance-free areas
Hobby	X							Probably sensitive to disturbance but relatively dispersed species
Peregrine	X	A				X		Sensitive to disturbance close to nest and vulnerable to climbing activities in particular
Black Grouse (leks)		R	P		X	X		Requires disturbance-free lekking areas
Quail	X	R		X	X			Widely dispersed species with only sporadic/occasional occurrence as a breeding bird. Not known if particularly sensitive to disturbance. Temporary restrictions on dogs may be necessary in ‘quail years’ when bird may occur in higher densities.
Spotted Crake	X	A		X	X			Wetland habitats relatively inaccessible. No evidence of particular sensitivity to disturbance.
Corncrake	X	R	P	X	X			Currently only one recently established, potentially regular breeding location, where access restricted. Not known if sensitive to disturbance.
Crane		A		X	X	X		Very rare breeding bird with only 2-3 regular sites. Appears sensitive to disturbance.
Oystercatcher		A				X	X	Largely breeding in coastal areas with evidence of decline in some areas, probably due, in part at least, to disturbance/nest trampling.
Avocet	X	A			X			Nests colonially, largely on saline and brackish lagoons.
Stone-curlew (breeding & roosting)	X	R	P		X	X	X	Known to be highly sensitive to disturbance and usually breeds on relatively small areas of habitat or specially managed plots.
Little Ringed Plover	X					X?		Associated with disturbed ground in active (or managed) gravel pits. Probably highly sensitive to disturbance but perhaps unlikely to be affected by changes to access.
Ringed Plover		A				X	X	Restricted to beaches and known to be adversely affected by recreational disturbance. At least one important population has suffered a large decline due, in part at least, to disturbance/nest trampling/predation.
Dotterel	X	A		X	X		X	Restricted to very restricted montane habitats popular with walkers. Now very scarce in England and no recent confirmed breeding.
Ruff	X	A		X	X	X		Requires disturbance-free lekking areas.

Black-tailed Godwit	X	R	P	X	X			Semi-colonial and thus more vulnerable to disturbance than other more dispersed waders. Very few breeding locations in England.
Mediterranean Gull	X	A		X	X	X	X	Colonial breeder – usually with Black-headed Gulls. Less than 15 regular breeding locations in England.
Black-headed Gull		A			X	X	X	Colonial breeder – around 20 important colonies with majority on the coast.
Lesser Black-backed Gull		A			X	X	X	Colonial breeder – around 10 important colonies with majority on coast.
Herring Gull		A	P		X	X	X	Colonial breeder – only 4 ground-nesting colonies of any significance.
Great Black-backed Gull					X	X	X	Colonial breeder – all significant colonies on the Isles of Scilly
Sandwich Tern		A			X	X	X	Colonial breeder – about 10 colonies, all at coastal locations.
Roseate Tern	X	R	P	X	X	X	X	Colonial breeder – largely restricted to single site with no current access.
Common Tern					X	X	X	Colonial breeder – majority nesting in coastal areas
Arctic Tern		A			X	X	X	Colonial breeder – only 4 colonies with two on islands with no or restricted access.
Little Tern	X	A			X	X	X	Colonial breeder – usually associated with beaches and known to be adversely affected by recreational access disturbance, nest trampling and predation.
Barn Owl	X	A						No evidence of particular sensitivity to disturbance. Widely dispersed species.
Nightjar		R	P			X		Associated with relatively restricted habitats and known to be adversely affected by recreational access. Relatively dispersed across suitable habitat.
Kingfisher	X	A						No evidence of particular sensitivity to disturbance. Widely dispersed species.
Woodlark	X	R	P			X		Associated with relatively restricted habitats and could be affected by changes in distribution of access. Relatively dispersed across suitable habitat.
Black Redstart	X	A		X	X			Associated with disturbed ground in urban areas and industrial sites. Not aggregated and no evidence of particular sensitivity to disturbance.
Cetti's Warbler	X							No evidence of particular sensitivity to disturbance. Relatively widely

							dispersed species though associated with wetland habitats of limited extent.
Marsh Warbler	X	R	P	X	X		A very rare breeding species, with majority of breeding birds restricted to a single, coastal site. No evidence of particular sensitivity to disturbance.
Dartford Warbler	X	A				X	Associated with relatively restricted habitats and known to be adversely affected by disturbance, notably by dogs. Relatively dispersed across suitable habitat.
Firecrest	X	A		X	X		Scarce but relatively widely dispersed and perhaps not particularly sensitive to disturbance.
Bearded Tit	X	A			X		Scarce breeder restricted to reedbeds. No evidence of particular sensitivity to disturbance.
Golden Oriole	X	A		X	X		Very small and declining breeding population restricted to poplar plantations in the fens.
Chough	X	A		X	X		Cliff-nesting species restricted to one coastal location. Probably sensitive to disturbance, including from climbers.
Crossbill	X						A sporadic breeding species at many locations. Relatively widely dispersed and not considered to be particularly sensitive to disturbance.
Cirl Bunting	X	R	P		X		Localised breeding species now the focus of a reintroduction project. No evidence of particular sensitivity to disturbance.

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