



A Model to Predict Wildlife Site Sensitivity to Visitor Pressure in Bedfordshire

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Sensitivity of Sites of Importance for Nature Conservation in Bedfordshire

Despite the abolition of regional planning, Bedfordshire faces a lot of growth pressure. Housing demand is high, as is demand for open space and natural areas. People want quality places in which to explore, recreate and commune with nature. Bedfordshire's natural areas are expected to face increasing visitor pressure, and many are thought to be suffering already.

Natural areas will have an inherent degree of sensitivity to visitor pressure. Being able to predict the degree of and reasons for site sensitivity could help inform habitat management.

Impacts of recreation on Sites of Importance to Nature Conservation

The effects of recreation on wildlife are many and varied. They depend on the features of both the ecology itself and of the recreation. The relatively new field of recreation ecology is the study of such effects, and volumes have been written on the impacts of various activities on different habitats and species. In general, recreational impacts on wildlife can consist of:

- Trampling, which causes floristic changes, vegetation loss, soil compaction and erosion
- Eutrophication, which leads to localised proliferation of weeds and alters the soil ecology
- Disturbance, which causes animal 'fight or flight' behaviours, site abandonment, and can lead to long term reduced fecundity
- Management interference, conflicts between recreational use and site management (e.g., sheep worrying, fence cutting, use of 'public-friendly' but suboptimal grazing stock breeds).

Factors related to site sensitivity

In this paper, 'sensitivity' should be interpreted as both inherent sensitivity and vulnerability. Healthy, diverse sites may exhibit low 'sensitivity', as diversity correlates with habitat resilience to disturbance. However such sites are also extremely vulnerable as their destruction would have a much greater biodiversity impact than the loss of less natural, diverse sites. Therefore some of the factors below relate to 'true' sensitivity (e.g., size, slope, presence of sensitive species) while others (e.g., rarity, establishment time) are perhaps better indicators of vulnerability.

Biotic factors

- **Rarity:** of plant and animal communities and species
- **Size and connectivity:** including degree of isolation from similar habitat
- **Representativeness/typicalness:** the degree to which plant and animal communities correspond to the 'ideal' for their type
- **Vegetation type:** dictates physical structure and species composition
- **Establishment time:** length of time needed to re-create the habitat were the site to be destroyed
- **Number of species:** relates to site size and habitat type
- **Presence of 'sensitive' species:** those whose needs cannot be met through standard habitat management

Abiotic factors

- Soil type and texture: dictate vegetation type and indicate resilience to compaction and erosion
- Topography: indicates resistance to soil erosion
- Degree of flooding/wetness: relate to soil erodibility

Developing a model to predict site sensitivity

The model presented here relates to the sensitivity of a site based on its ecological features. It incorporates a range of biotic and abiotic factors including those listed above (Table 1). Factors related to the amount and type of recreation faced by Bedfordshire's natural areas are not considered.

The model is based on work by Denyse Lajeunesse and colleagues from the Jardin botanique de Montréal (Table 1).¹ Their criteria and scoring system have been used in this study. The indicators, however, have been modified to use local and in some cases national data sets and indices. Quantitative indicators have been used where possible in an attempt to reduce bias and subjectivity.

Most of the data for this study came from the Bedfordshire and Luton Biodiversity Recording and Monitoring Centre (www.bedsbionet.org.uk). Soils information was from the National Soil Resources Institute's Soilscales Viewer (www.landis.org.uk/soilscales/).

Table 1 Criteria for evaluating the sensitivity of Bedfordshire wildlife sites to visitor pressure

Criteria	Maximum score
Biotic value: vegetation	
Uniqueness of plant community type	5
Representativity	5
Succession-disturbance degree	5
Rarity (number of rare species)	5
Richness (total number of species)	5
Biotic value: avifauna	
Uniqueness of wildlife habitat type	5
Representativity	5
Rarity (number of rare species)	5
Importance for wildlife	5
Maximum total	45
Abiotic value	
Drainage	6
Submersibility	6
Texture	6
Slope	3
Maximum total	21

Data used to analyse some of the factors outlined below relate to broad habitat types (primarily farmland and woodland), so sites need to be assigned accordingly. Many of Bedfordshire's natural areas include a mix of these. In some cases it will make sense to 'split' a site and calculate separate sensitivity indices for the different compartments. In others a single index will suffice. Sites can be highly complex and 'lumping' a site's habitats

¹ Lajeunesse D, Domon G, Drapeau P, Cogliastro A, Bouchard A. 1995. Development and application of an ecosystem management approach for protected natural areas. *Environmental Management* 19(4): 481-495.

into a single category can be regarded as a weakness of the model. None of the test sites used in this preliminary analysis have been split; this has only been done for the sake of simplicity. It remains to be seen for which sites splitting would be appropriate.

Biotic Value: Vegetation

Uniqueness of plant community type

Lajeunesse et al based this criterion on three elements: position along a successional gradient, regional distribution and degree of restriction to a particular habitat.²

Assessment method and rationale

This criterion has been interpreted to mean 'habitat rarity'. Defining either 'uniqueness' or 'rarity' can be challenging. Assessing the distribution of specific National Vegetation Classification (NVC) plant communities is also problematic, as such specific national – or even county – inventories are not available.

A simpler process is to calculate the scarcity of BAP habitats, each of which may include several NVCs. The local extent of many of Bedfordshire's BAP habitats is known. National coverage estimates for these habitats are available from the Biodiversity Action Reporting System (BARS)³. By comparing the local amount of a particular habitat to the national area, one can get a sense of habitat rarity, and how much of the national resource is located in Bedfordshire.

England is approximately 130,395km² in area; Bedfordshire comprises 1235km² of this. If BAP habitats were distributed evenly across the country one would expect Bedfordshire to have 0.9% of each. Habitats of which Bedfordshire has significantly more than 0.9% could be regarded as having extra importance since Bedfordshire would have more than its 'fair share'. In evaluating habitat rarity/uniqueness, both the absolute and relative abundance of the habitat must be taken into account.

Scoring

The scores consider both national and local rarity: habitats which are both nationally and locally rare score higher than those which are locally rare but nationally more common. 'Common' habitats are those which comprise more than 5% of the total BAP habitat nationally or locally, as appropriate. 'Uncommon' habitats comprise between 1% and 5%, and 'rare' habitats represent less than 1% of the total BAP habitat resource. Habitats which are restricted to certain soil types or moisture regimes also score higher than those which can occur anywhere. Scores for each of Bedfordshire's UK BAP Priority Habitats are presented in Table 2.

² Lajeunesse D, Domon G, Drapeau P, Cogliastro A, Bouchard A. 1995. Op cit.

³ www.ukbap-reporting.org.uk

Table 2 Habitat ‘uniqueness’ scores for Bedfordshire and Luton’s Biodiversity Action Plan habitats

Habitat	Local status	National status	Score	Restricted distribution	Score (adjusted)
Arable field margins	Uncommon	Uncommon	3	No	3
Floodplain grazing marsh	Rare	Common	4	Yes	5
Lowland calcareous grassland	Uncommon	Uncommon	4*	Yes	5
Lowland dry acid grassland	Uncommon	Uncommon	3	Yes	4
Lowland heathland	Rare	Uncommon	4	Yes	5
Lowland meadow	Rare	Rare	5	Yes	5
Lowland mixed deciduous woodland	Common	Common	0	No	0
Reedbed	Rare	Rare	5	Yes	5
Wet woodland	Uncommon	Uncommon	4**	Yes	5

* higher score of 4 due to local importance and contiguity of the resource

** higher score as Bedfordshire has significantly higher proportion of the national resource than would be expected

Advantages

- Value easily assigned once initial calculations are complete

Disadvantages

- Regional comparison not available, only national

Representativity

This criterion compares the plant species community of a site to a ‘typical’ plant community. It therefore reflects how closely the habitat approaches a ‘textbook’ example of its type.

Assessment method and rationale:

Natural England Site of Special Scientific Interest (SSSI) selection guidelines indicate that representativeness and typicalness are often equated with one another.⁴ The guidelines also refer to ‘representativeness’ as comprising many factors, primarily typicalness and diversity. Other vegetation criteria in the Lajeunesse model address diversity, and the above definition of representativity implies that typicalness is in fact the intended meaning.

Typicalness is used to select both SSSIs and County Wildlife Sites⁵, the two most common site designations in Bedfordshire and Luton. Designation can therefore be used as a proxy for typicalness/representativity.

Scoring

The scoring system is based on a site’s highest conservation designation (Table 3). The highest scoring sites are Special Areas of Conservation (SACs) which are important at a European scale. The lowest scoring sites are those with no designation at all. One weakness of this system is that sites which may be excellent examples of their type but cannot for various reasons be designated, will be scored too low. Such sites may be scored according to the designation they would otherwise achieve. However to do this would expose the scoring to subjectivity.

⁴ Nature Conservancy Council. 1989. Guidelines for selection of biological SSSIs. Part B: Operational Approach and Criteria, p. 23.

⁵ Bedfordshire and Luton Local Sites Partnership. 2010. Bedfordshire and Luton County Wildlife Sites selection guidelines, Version 3, p. 5.

Table 3 Representativity scores for Bedfordshire and Luton's natural areas

Points	
0	No nature conservation designation
1	Local Nature Reserve (LNR)
2	County Wildlife Site (CWS)
3	Site of Special Scientific Interest (SSSI)
4	National Nature Reserve (NNR)
5	Special Area of Conservation (SAC)

Advantages

- Value easily assigned

Disadvantages

- Potential for subjectivity
- Qualitatively derived

Succession-disturbance degree

This criterion relates to a site's response to various types of disturbance.

Assessment method and rationale

Habitats can face a range of disturbance types. For this criterion, five key factors are used to evaluate a site's ability to respond to disturbance. Three of these are habitat-based and two are site based. The five factors considered are:

1. establishment time: habitat destruction is the most extreme form of disturbance; habitats which take longer to re-establish can therefore be viewed as more sensitive than those which re-establish quickly.
2. potential for rare species: habitats which can support many rare plant species may be considered more sensitive than those with fewer rare species. Rare (and threatened and declining, i.e. potentially rare) species in the UK can be represented by the UK BAP Priority Species list and Red Data lists. For the present purposes and in the absence of a current national or local Red Data Book for vascular plants, the UK BAP list has been used.
3. need for grazing: many of Bedfordshire's habitats either require or benefit greatly from grazing by livestock. However sheep worrying, fence cutting and other forms of livestock/visitor conflicts are common in some areas. Habitats which need grazing can therefore be regarded as sensitive.
4. presence of species with narrow ecological tolerance: the UK BAP Priority Species list identifies species with needs which cannot be met through standard habitat management, and which consequently require 'single species action'.⁶ Twelve such plant species have been recorded in Bedfordshire.
5. 'ancient' sites: the soils of sites which have been habitat for many years (e.g., non-coniferised or planted ancient woodlands, some ridge and furrow) likely have a robust ecology, better able to support important plant communities.

Scoring

The scoring system allocates up to a full point for each of the above factors, as follows (Table 4):

⁶ Biodiversity Reporting and Information Group. 2007. Report on the Species and Habitat Review. Report to the UK Biodiversity Partnership, p.13.

Table 4 Succession-disturbance degree scoring system for Bedfordshire and Luton's natural areas

Habitat-specific factors	
Establishment time	0.1 point for each 10 years time to re-create habitat ⁷
Potential for rare species	Proportion of BAP plant species* potentially supported by the habitat type, relative to lowland calcareous grassland (15 species = 100% = 1 point)
Need for grazing	1 point for habitats requiring grazing
	0.5 points for habitats which can be grazed or cut
	0 points for habitats not requiring grazing
Site-specific factors	
Presence of species with narrow ecological tolerance	1 point for the presence of a BAP species identified as needing single species action
Ancient sites	1 point for the probable existence of an ancient soil ecology

* BAP species recorded in Bedfordshire

Rarity

This criterion relates to the number of rare plant species recorded on a site.

Assessment method and rationale

Rare (and threatened and declining, i.e. potentially rare) species in the UK can be represented by the UK BAP Priority Species list and Red Data lists. Red Data Lists traditionally included purely 'rare' species. The UK BAP Priority Species list also considers decline, degree of threat and other factors. It therefore offers a more comprehensive indication of species' conservation prospects and is a useful proxy for a rare species list. For the present purposes and in the absence of a current national or local Red Data Book for vascular plants, the UK BAP list has been used.

Bedfordshire is home to 42 UK BAP vascular plant species (Appendix 1). Not all of these are likely to be present in a given site; rather each will be restricted to certain habitat types, e.g., wetland, woodland, grassland, farmland. However it is possible to compare in general terms the number of rare species present on a site to what might be found in 'ideal' habitat.

Scoring

The scoring system relates to the percentage of possible rare species which have been recorded on a site. It is unrealistic to expect a single habitat patch to harbour all possible rare species. Instead the proposed scoring system uses the '80/20 rule', whereby a site which has at least 80% of the potential rare species would score a full 5/5. In other words:

$$\text{Rarity} = \frac{\left(\frac{\text{number of UK BAP species recorded}}{\text{number of potential UK BAP species for the county and habitat type}} \right) \times 100 \times 5}{80}$$

to a maximum of 5

⁷ Bastian O, Schreiber K-F. 1999. Analyse und ökologische Bewertung der Landschaft. 2nd ed. Heidelberg: Spektrum, p. 298. As cited in Goedkoop M, Heijungs R, Huijbregts M, De Schryver A, Struijs J, van Zelm R. 2009. ReCiPe 2008: a life cycle impact assessment method which comprises harmonised category indicators at the midpoint and endpoint level, 1st ed. Report 1: Characterisation, p.98.

Advantages

- Quantitative
- Easily calculated

Disadvantages

- Sites can have more than one habitat type
- Needs to be updated as new records are obtained
- Relies on having sufficient data, recording intensity
- Does not consider area effects

Richness

This criterion relates to the total number of plant species.

Assessment method and rationale

It is well established that species richness increases with area. A conventional way of representing this relationship is the formula

$$S = cA^z$$

Where S = species richness (# of species)

A = area (in m² for the c and z values below)

c and z are constants⁸

Values for c and z have over the years been calculated by many investigators and for a range of habitats. In the 1980s botanist John Dony calculated c and z values for Bedfordshire's grassland and woodland habitats.⁹ These are extremely useful, having been derived for local conditions. Two other sets of values which have been calculated for UK habitats and therefore might be useful for the present purposes have been reported by Goedkoop et al (2009)¹⁰ and Crawley and Hurrall (2001)¹¹. Figures from all three sources are depicted in Table 5.

These figures can be used to estimate a theoretical species richness, to which the actual number of recorded species can be compared. The theoretical maximum will of course be limited by the actual number of species found in Bedfordshire's habitats. The National Biodiversity Network includes records for approximately 2350 vascular plant species, subspecies and varieties in Bedfordshire. Not all of these will be found in all habitats. Table 6 includes the approximate maximum number of species expected in each of the county's BAP habitats.^{12 13 14}

⁸ MacArthur RH, Wilson EO. 1967. *The Theory of Island Biogeography*. Princeton, New Jersey: Princeton University Press, p. 17.

⁹ Dony J. Date unknown. A measurement of the floristic richness indices of natural history interest. Unpublished, p.6-14.

¹⁰ Goedkoop M, Heijungs R, Huijbregts M, De Schryver A, Struijs J, van Zelm R. 2009. ReCiPe 2008: a life cycle impact assessment method which comprises harmonised category indicators at the midpoint and endpoint level, 1st ed. Report 1: Characterisation, p.100

¹¹ Crawley MJ, Hurrall JE. 2001. Scale dependence in plant biodiversity. *Science* 291: 264-268.

¹² Rose F. 2006. *The Wild Flower Key*. 2nd edition. London: Penguin Books Ltd.

¹³ Botanical Society of the British Isles. Date unknown. Identify a Plant: Flora Search [ONLINE] <http://www.botanicalkeys.co.uk/flora/content/SEARCH.ASP>.

¹⁴ Hubbard CE. 1984. *Grasses: a Guide to Their Structure, Identification, Uses and Distribution*. London: Penguin Books Ltd.

Table 5 Vascular plant species richness factor c and species accumulation factor z for land use types in Bedfordshire and Luton

Land use type	z	c
Heaths and acid grassland *	0.478	6.124
Neutral grassland *	0.019	6.095
Chalk grassland/downland *	0.181	17.62
Wetland (reedbed, floodplain grazing marsh) *	0.347	9.683
Intensive crops/weeds †	0.210	4.6
Extensive crops/weeds (including arable margins) †	0.210	6.2
Intensive fertile grassland †‡	0.349	6.2
Extensive fertile grassland †‡	0.349	7.9
Extensive broadleaf, mixed and yew lowland woodland *	0.463	4.864
Broadleaf plantation †‡	0.439	3.3
Coniferous plantation †‡	0.439	2.8
Mixed plantation †‡	0.439	1.8
Continuous urban †‡	0.214	1.4
Vineyard †	0.210	2.8

Source: * Dony; † Goedkoop et al. 2009; ‡ Crawley and Harral, 2001.

Table 6 Approximate maximum vascular plant species richness of Biodiversity Action Plan habitats in Bedfordshire and Luton

Habitat type	Maximum species richness (approx.)
Acid grassland	400
Arable field margin	350
Chalk grassland	470
Floodplain grazing marsh	250
Heathland	170
Lowland meadow	420
Ponds	200
Reedbed	250
Traditional orchard	300
Wet woodland	250
Woodland	500
Wood-pasture/parkland	320

Observed species richness *S* varies widely, even among sites of similar habitat and size.¹⁵ It will also vary with recording intensity. Small sites closer to urban areas may be recorded more intensively than larger, more rural sites. Results should therefore be treated as purely indicative.

¹⁵ Crawley MJ, Harral JE. 2001. Op cit.

Scoring

Many of Bedfordshire's wildlife sites are remnants of once much larger or contiguous (in either case more species rich) areas of habitat. It can therefore be expected that over time species richness has diminished as these remnants have become increasingly isolated and undergone more environmental and anthropogenic pressure. In such a landscape sites are unlikely to have the full number of predicted species. Exceptions might of course arise, such as sites recently isolated from the surrounding matrix, and where the 'crowding on the Ark' phenomenon is occurring. Therefore sites exhibiting at least 80% of the theoretical species richness score full marks.

With this in mind, and based on calculations from a number of test sites, a species richness scoring system is (Table 7):

Table 7 Vascular plant species richness scores for Bedfordshire and Luton's natural areas

Points	
0	Site has <40% of predicted species richness
1	Site has 40-50% of predicted species richness
2	Site has 50-60% of predicted species richness
3	Site has 60-70% of predicted species richness
4	Site has 70% - 80% of predicted species richness
5	Site has \geq 80% of predicted species richness

Advantages

- Quantitative
- Easily calculated

Disadvantages

- Sites can have more than one habitat type
- Needs to be updated as new records are obtained
- Relies on having sufficient data, recording intensity

Biotic value: avian fauna

Uniqueness of wildlife habitat type

This criterion relates to the importance of a habitat patch relative to the surrounding matrix.¹⁶

Assessment method and rationale

Bedfordshire's wildlife sites are 'islands of green', habitat patches within a human-dominated matrix. As such they are important residential or stepping-stone habitat for the area's bird species. Moving between patches carries a variety of costs, which relate to among other things the distance between patches, the quality of the patches themselves, and the quality of the intervening matrix.

One way to represent the quality of the matrix land cover is to evaluate the costs to a species of interacting with it. High quality matrix will have feeding and resting opportunities. Poor quality land cover will not. As a result, poorer quality matrix habitat will generate higher interaction costs to individual animals. By analysing the matrix around a wildlife site one can get a feel for the difference between the site – the habitat patch – and the matrix. 'Unique'

¹⁶ Note that 'uniqueness' in this context refers to the relative importance of habitat, rather than rarity as it does above under biotic value for vegetation.

habitat can be considered to be those patches surrounded by the most costly matrix. Such costs are available or can be calculated for a variety of species. Nikolakaki (2004) offers a series of 'landscape resistance values' for the redstart *Phoenicurus phoenicurus* (Table 8).¹⁷ While these values were derived for a single species, they are likely a good proxy which can be applied to songbirds in general. It should be noted however that these figures do not necessarily apply to all species, or to the entire life cycle of any one species.

Table 8 Landscape resistance values for the redstart *Phoenicurus phoenicurus* (Nikolakaki 2004)

Land cover class	Landscape resistance value
Deciduous woodland	1
Mixed woodland	2
Woody wetland (wet woodland)	2
Conifer woodland	3
New plantation	3
Bracken/grass heath with mature trees	4
Rough grassland with mature trees	4
Permanent pasture/meadow with mature trees	4
Amenity grassland	5
Bracken/grass heath with scrub	5
Bracken/grass heath with heather	5
Bracken and/or grass heathland	5
Rough grassland with scrub	5
Rough grassland including marshland	5
Permanent pasture/meadow with scrub	5
Permanent pasture and meadow	5
New and/or improved grassland	5
Cultivated crops	10
Allotments	10
Permanent horticultural crops	10
Urban	20
Mineral workings, active pits, tips, spoil heaps	20
Open water	25
Rivers	25
Roads	25
Rail	25

Mobile species have home ranges within which they forage, patrol territories and search for mates. This range varies among species and activities. However for the current exercise it is necessary to select a baseline range size so that results can be compared. Hughes et al (2002) suggest that most bird species would be unlikely to travel more than 2km for routine

¹⁷ Nikolakaki P. 2004. A GIS site-selection process for habitat creation: estimating connectivity of habitat patches. *Landscape and Urban Planning* 68: 77-94.

activities¹⁸, and so that figure is used here. This 2km radius does not include travel for migratory purposes, but rather for daily activities.

Scoring

Using the values in Table 8 above, the simplest way to score habitat uniqueness is simply to convert to a value /5 the value for the dominant land use within 2km of the patch. The system is easily adaptable, however, to those situations where the surrounding matrix is a mix of two or more primary land use types (e.g., urban fringe areas). For example, where the surrounding area is a 50/50 mix of urban development and pasture, one could calculate the average cost of $(20 + 10)/2 = 15$. This translates to a value of $3/5$.

Advantages

- Quantitative
- Easily calculated
- Adaptable

Disadvantages

- Figures not species-specific

Representativity

This criterion relates to the degree to which a bird community reflects a reference bird community type.

Assessment method and rationale

The British Trust for Ornithology has outlined 'reference bird community types' in its set of Wild Bird Indicators (Appendix 3). These indicators are available for farmland birds, woodland birds and wintering waterbirds. This habitat breakdown corresponds well to those used above in calculations of floristic value. By comparing the list of species recorded to the list of indicator species one can determine how close a local avian community approaches the 'ideal' community for the habitat. Major drawbacks of this method are that

- a) A site can and often does include more than one habitat type
- b) The highly mobile nature of birds means that non-resident individuals may have still been recorded for that site (e.g., flying overhead, identified by song); this would apply in particular to small sites
- c) Woodland birds will have been recorded on farmland sites and vice versa. For many sites it may be necessary to evaluate both sets of species to obtain a true profile of the local bird community.

Scoring

The scoring system relates to the percentage of bird indicator species which have been recorded on a site. It is unrealistic to expect a site to harbour all possible indicator species for the habitat. Instead the proposed scoring system uses the '80/20 rule', whereby a site which has at least 80% of the potential rare species would score a full 5/5. In other words:

$$\text{Rarity} = \frac{\left(\frac{\text{number of indicator species recorded}}{\text{number of species on the indicator list}} \right) \times 100 \times 5}{80} \text{ to a maximum of 5}$$

¹⁸ Hughes JB, Daily GC, Ehrlich PR. 2002. Conservation of tropical forest birds in countryside habitats. *Ecology Letters* 5: 121-129.

Advantages

- Quantitative
- Easily calculated

Disadvantages

- Sites can have more than one habitat type
- Possible over-recording, especially on small sites
- Birds not restricted to farmland, woodland etc.

Rarity

This criterion relates to the number of rare bird species recorded on a site.

Assessment method and rationale

Rare (and threatened and declining, i.e. potentially rare) species in the UK can be represented by the UK BAP Priority Species list and Red Data lists. Red Data Lists traditionally included purely 'rare' species. The UK BAP Priority Species list also considers decline, degree of threat and other factors. It therefore offers a more comprehensive indication of species' conservation prospects and is a useful proxy for a rare species list. For the present purposes the UK BAP list has been used.

Bedfordshire is home to 40 UK BAP bird species (Appendix 2). Not all of these are likely to be recorded at a given site; rather each will be attracted to certain habitat types, e.g., wetland, woodland, grassland, farmland. Their mobility allows birds to be much less restricted than plants in their habitat choice. However it is possible to compare in general terms the number of rare species present on a site to what might be found in 'ideal' habitat.

Scoring

The scoring system relates to the percentage of UK BAP species which have been recorded on a site. It is unrealistic to expect a site to harbour all possible BAP species for the habitat. Instead the scoring system uses the '80/20 rule', whereby a site which has at least 80% of the potential rare species would score a full 5/5. In other words:

$$\text{Rarity} = \frac{\left(\frac{\text{number of UK BAP species recorded}}{\text{number of potential UK BAP species for the county and habitat type}} \right) \times 100 \times 5}{80}$$

to a maximum of 5

Advantages

- Quantitative
- Easily calculated

Disadvantages

- Sites can have more than one habitat type
- Birds not restricted to farmland, woodland etc.

Importance for wildlife

This criterion considers whether a site has areas, structure or habitat critical to a species' life cycle.

Assessment method and rationale

Examples of important areas for wildlife include 'a colonial nesting site that supports an important portion of the regional or national population of a given species, staging areas for migrating birds, brood-rearing areas for waterfowl, or nesting sites of avian top predators.'¹⁹

Scoring

Scores relate to the conservation status of the species of interest for the site (Table 9). The RSPB and partners regularly review the conservation status of Britain's bird species, ranking them on one of three lists: red, amber and green. Red list species are the most threatened. Therefore important areas for red list species are more sensitive than those for amber list species, which in turn are more sensitive than those for green list species.

Table 9 Avian wildlife importance scores for Bedfordshire and Luton's natural areas

Points	
0	No important areas for wildlife known
1	Important area for green-listed species
3	Important area for amber-listed species
5	Important area for red-listed species

Advantages

- Value easily assigned

Disadvantages

- Qualitative
- Requires detailed local knowledge

Abiotic value

Abiotic criteria are related to the erodability of soils. Trampling has two key effects on soils: it abrades the organic soil horizons and compacts the soil. Compaction reduces soil porosity. With the exception of some coarse-textured soils, this in turn reduces water holding capacity. Decreased infiltration leads to the potential for greater runoff and erosion.²⁰ In general, wet soils and those with a narrow range of small particle sizes (e.g., silt) are more at risk of erosion.

Drainage

Assessment method and rationale

This method categorises soils into three drainage classes.

Soil type can be derived using NatMap Soilscales, which is available online or as a GIS. The drainage class can then be inferred using the National Soil Resources Institute (NSRI) online 'Soilscales Viewer'.²¹ This online mapping tool provides drainage type, fertility and texture and other information on 27 broad soil types in England and Wales. Drainage types used in Soilscales can be assigned to the above classes as follows (Table 10):²²

¹⁹ Lajeunesse D, Domon G, Drapeau P, Cogliastro A, Bouchard A. 1995. Op cit.

²⁰ Cole DN. 2004. Impacts of hiking and camping on soils and vegetation. In: Buckley R (Ed). *Environmental Impacts of Ecotourism*. New York: CABI Publishing, 41-60.

²¹ National Soil Resources Institute. 2010. Soilscales <http://www.landis.org.uk/soilscales/> [ONLINE]. Accessed 10 May 2010.

²² MAGIC. 2010. Dataset Information: Soilscale (England), Soil <http://www.magic.gov.uk/DataDoc/Information/soilscales.pdf> [ONLINE]. Accessed 6 May 2010.

Scoring

The drainage classes are assigned a point value based on soil fragility, either 0, 3 or 6 points accordingly:

Table 10 Drainage scores for National Soil Resources Institute soil types

	Points	Natural drainage type per NSRI
Good to moderate drainage	0	Freely draining Slightly impeded drainage
Imperfect drainage	3	Impeded drainage Variable
Poor to very poor drainage	6	Naturally wet Surface wetness

Advantages

- Value easily assigned
- Information freely available online

Disadvantages

- Qualitative/subjective threshold

Submersibility

This criterion relates to the probability of a site flooding.

Assessment method and rationale

Using this method, sites are assigned to one of three classes: never submerged, easily flooded or regularly submerged. Sites which are never or always submerged are easy to identify, using a combination of local knowledge and topographical and water table information. 'Easily flooded' sites could be more difficult to identify. For the purposes of this exercise easily flooded sites constitute those in the floodplain for which the Environment Agency has identified a 'significant' (i.e. greater than 1/75; 1.3%) flood risk.²³

Scoring

The submersibility classes are assigned a point value based on soil fragility, either 0, 3 or 6 points accordingly (Table 11):

Table 11 Soil submersibility scores and classes for Bedfordshire and Luton's natural areas

Points	Submersibility	EA Flood Zone	Fragility
0	Never submerged	3	Not fragile
3	Easily flooded	2	Moderately fragile
6	Regularly submerged	1	Severely fragile

Advantages

- Value easily assigned
- Information freely available online

Disadvantages

- Qualitative/subjective threshold

²³ Environment Agency. 2010. Flood map [ONLINE]. Available at <http://www.environment-agency.gov.uk/homeandleisure/floods/31650.aspx>. Accessed 18 October 2010.

Texture

This criterion relates to the relative percentages of sand, silt and clay in a soil.

Assessment method and rationale

Soil texture provides an indication of resilience to compaction. Soils with fine, uniformly sized particles (e.g., silts, clays) are at greater risk of compaction than sandy soils or loams, which have large or unevenly sized particles.

Scoring

Soil type can be determined using NatMap Soilscales, using GIS. The texture class can then be inferred using the National Soil Resources Institute online 'Soilscales Viewer'.²⁴ This online mapping tool provides drainage type, fertility and texture and other information on 27 broad soil types in England and Wales. Main surface texture class used in Soilscales can be assigned to the above classes as follows (Table 12).²⁵

Table 12 Soil texture scores based on National Soil Resources Institute surface texture class

	Points	Main surface texture class per NSRI
Loam; sandy loam; sandy-clay loam	0	Sandy
Other loams	3	Loamy
Organic soils; clay	6	Clayey Peaty

Note that the first category includes some sandy loams. Soilscales has assigned soils with a significant percentage of sand or clay-sand to the 'sandy' surface texture class.

Advantages

- Value easily assigned
- Information freely available online

Disadvantages

- Qualitative/subjective threshold

Slope

Assessment method and rationale

Even topographically 'simple' sites do not have 'one' slope but many. The steeper the slope, the more risk of soil erosion from natural or anthropogenic processes. The simplest way to evaluate this criterion is to measure a site's steepest slope. This can be done in GIS using a simple 'rise over run' calculation.

Scoring

Scores are based on risk categories in the Higher Level Stewardship Farm Environment Plan (FEP) Manual.²⁶ A FEP requires an assessment of soil erosion risk on fields in a farm holding. The effects of slope vary with the soil texture, and the FEP manual provides a simple table for evaluating the soil erosion risk for each of these (Table 13). Soil textures have for this purpose been divided into three classes which approximate the sandy, loamy and clayey categories used above.

²⁴ National Soil Resources Institute. 2010. Op cit.

²⁵ MAGIC. 2010. Op cit.

²⁶ Natural England. 2010. Higher Level Stewardship Farm Environment Plan (FEP) Manual. 3rd edition. Peterborough: Natural England, p. 122.

Table 13 Site topographical slope scores by degree and soil type

Soils	Steep slopes >7° (>12%)	Moderate slopes 3°-7° (5-12%)	Gentle slopes 2°-3° (3-5%)	Level ground <2° (<3%)
Sandy and light silty soils (sandy)	Very high	High	Moderate	Lower
Medium and calcareous soils (loamy)	High	Moderate	Lower	Lower
Heavy soils (clayey)	Lower	Lower	Lower	Lower

As this criterion is scored out of three the erosion risk categories in Table 13 could be scored in the following manner (Table 14):

Table 14 Topographical slope scores for Bedfordshire and Luton's natural areas

Points	Erosion risk
0	Lower
1	Moderate
2	High
3	Very high

Advantages

- Value easily assigned
- Precision
- Already accepted for use in the UK

Disadvantages

- Does not consider land use or cover
- Agricultural focus

Ecological sensitivity values and classes

Thresholds set by Lajeunesse et al for vegetation, avian and abiotic sensitivity have been adopted here, with one modification. Sufficient data were not available to evaluate avian relative species abundance and so the 'quality of bird community type' criterion has not been included in this model. The avian sensitivity threshold score has been adjusted accordingly. The full suite of sensitivity score thresholds is presented in Table 15.

Table 15 Bedfordshire and Luton wildlife site sensitivity class scores and thresholds

	Sensitivity class			
	Very high	High	Low	Very low
Vegetation sensitivity	≥20	15-19	10-14	<10
Avian sensitivity	≥16	12-15	8-12	<8
Abiotic sensitivity	≥12	6-11	3-5	<3

Using this model

Visitor impacts on natural areas result from a combination of inherent ecological sensitivity and the features of the visitor pressure (e.g., intensity, duration, seasonality, type of recreation). The model presented here offers a scientific, objective way to predict inherent

site sensitivity. For a complete picture of visitor impacts on a site's ecology these results should be evaluated together with those of visitor impact studies.

It must also be noted that site sensitivity is not the same as ecological value or importance. Sites of 'low sensitivity' still have ecological value, and visitor impact studies should be done to ensure that increased visitor pressure does not damage important ecological features. Recreational site uses which are likely to harm such features should not be considered.

Appendix 1 UK Biodiversity Action Plan vascular plant species recorded in Bedfordshire and Luton

Scientific name	Common name
<i>Aceras anthropophorum</i>	Man Orchid
<i>Adonis annua</i>	Pheasant's-eye
<i>Ajuga chamaepitys</i>	Ground-pine
<i>Astragalus danicus</i>	Purple Milk-vetch
<i>Blysmus compressus</i>	Flat-sedge
<i>Bupleurum rotundifolium</i>	Throw-wax
<i>Carum carvi</i>	Caraway
<i>Centaurea calcitrapa</i>	Red Star-thistle
<i>Centaurea cyanus</i>	Cornflower
<i>Cephalanthera damasonium</i>	White Helleborine
<i>Chenopodium urbicum</i>	Upright Goosefoot
<i>Clinopodium acinos</i>	Basil Thyme
<i>Coeloglossum viride</i>	Frog Orchid
<i>Euphrasia pseudokernerii</i>	Chalk Eyebright
<i>Galeopsis angustifolia</i>	Red Hemp-nettle
<i>Galium tricornutum</i>	Corn Cleaver
<i>Herminium monorchis</i>	Musk Orchid
<i>Hordeum marinum</i>	Sea Barley
<i>Iberis amara</i>	Wild Candytuft
<i>Juniperus communis</i>	Juniper
<i>Lolium temulentum</i>	Darnel
<i>Melampyrum cristatum</i>	Crested Cow-wheat
<i>Melittis melissophyllum</i>	Bastard Balm
<i>Mentha pulegium</i>	Pennyroyal
<i>Minuartia hybrida</i>	Fine-leaved Sandwort
<i>Monotropa hypopitys</i>	Yellow Bird's-nest
<i>Monotropa hypopitys subsp. hypophegea</i>	Bird's-nest
<i>Muscari neglectum</i>	Grape-hyacinth
<i>Oenanthe fistulosa</i>	Tubular Water-dropwort
<i>Ophrys insectifera</i>	Fly Orchid
<i>Orchis ustulata</i>	Burnt Orchid
<i>Potamogeton compressus</i>	Grass-wrack Pondweed
<i>Pulsatilla vulgaris</i>	Pasqueflower
<i>Ranunculus arvensis</i>	Corn Buttercup
<i>Scandix pecten-veneris</i>	Shepherd's-needle
<i>Scleranthus annuus</i>	Annual Knawel
<i>Silene gallica</i>	Small-flowered Catchfly
<i>Sium latifolium</i>	Greater Water-parsnip
<i>Stellaria palustris</i>	Marsh Stitchwort
<i>Tephrosieris integrifolia subsp. integrifolia</i>	Field Fleawort
<i>Torilis arvensis</i>	Spreading Hedge-parsley
<i>Valerianella rimosa</i>	Broad-fruited Cornsalad

Appendix 2 UK Biodiversity Action Plan bird species recorded in Bedfordshire and Luton

Scientific name	Common name
<i>Alauda arvensis</i> subsp. <i>arvensis/scotica</i>	Skylark
<i>Anser albifrons</i> subsp. <i>albifrons</i>	White-fronted Goose
<i>Anthus trivialis</i>	Tree Pipit
<i>Aythya marila</i>	Greater Scaup
<i>Branta bernicla</i> subsp. <i>bernicla</i>	Dark-bellied Brent Goose
<i>Caprimulgus europaeus</i>	European Nightjar
<i>Carduelis cabaret</i>	Lesser Redpoll
<i>Carduelis cannabina</i> subsp. <i>autochthona/cannabina</i>	Common Linnet
<i>Carduelis flavirostris</i> subsp. <i>bensonorum/pipilans</i>	Twite
<i>Coccothraustes coccothraustes</i>	Hawfinch
<i>Cuculus canorus</i>	Common Cuckoo
<i>Cygnus columbianus</i> subsp. <i>bewickii</i>	Bewick's Swan
<i>Dendrocopos minor</i> subsp. <i>comminutus</i>	Lesser Spotted Woodpecker
<i>Emberiza calandra</i> subsp. <i>calandra/clanceyi</i>	Corn Bunting
<i>Emberiza citrinella</i>	Yellowhammer
<i>Emberiza schoeniclus</i>	Reed Bunting
<i>Gavia arctica</i>	Black-throated Diver
<i>Jynx torquilla</i>	Eurasian Wryneck
<i>Lanius collurio</i>	Red-backed Shrike
<i>Larus argentatus</i> subsp. <i>argenteus</i>	Herring Gull
<i>Limosa limosa</i> subsp. <i>limosa</i>	Black-tailed Godwit
<i>Locustella naevia</i>	Common Grasshopper Warbler
<i>Lullula arborea</i>	Woodlark
<i>Melanitta nigra</i>	Common Scoter
<i>Motacilla flava</i> subsp. <i>flavissima</i>	Yellow Wagtail
<i>Muscicapa striata</i>	Spotted Flycatcher
<i>Numenius arquata</i>	Eurasian Curlew
<i>Passer domesticus</i>	House Sparrow
<i>Passer montanus</i>	Eurasian Tree Sparrow
<i>Perdix perdix</i>	Grey Partridge
<i>Phylloscopus sibilatrix</i>	Wood Warbler
<i>Poecile montanus</i> subsp. <i>kleinschimdti</i>	Willow Tit
<i>Poecile palustris</i> subsp. <i>palustris/dresseri</i>	Marsh Tit
<i>Prunella modularis</i> subsp. <i>occidentalis</i>	Dunnock/Hedge Accentor
<i>Pyrrhula pyrrhula</i> subsp. <i>pileata</i>	Common Bullfinch
<i>Streptopelia turtur</i>	Turtle Dove
<i>Sturnus vulgaris</i> subsp. <i>vulgaris</i>	Common Starling
<i>Turdus philomelos</i> subsp. <i>clarkei</i>	Song Thrush
<i>Turdus torquatus</i>	Ring Ouzel
<i>Vanellus vanellus</i>	Northern Lapwing

Appendix 3 British Trust for Ornithology Wild Bird Indicator farmland, woodland and wintering waterfowl species

Farmland		Woodland	
<i>Carduelis cannabina</i>	Linnet	<i>Accipiter nisus</i>	Sparrowhawk
<i>Carduelis carduelis</i>	Goldfinch	<i>Aegithalos caudatus</i>	Long-tailed tit
<i>Carduelis chloris</i>	Greenfinch	<i>Certhia familiaris</i>	Treecreeper
<i>Columba oenas</i>	Stock dove	<i>Dendrocopos major</i>	Great-spotted woodpecker
<i>Columba palumbus</i>	Woodpigeon	<i>Erithacus rubecula</i>	Robin
<i>Corvus frugilegus</i>	Rook	<i>Fringilla coelebs</i>	Chaffinch
<i>Corvus monedula</i>	Jackdaw	<i>Garrulus glandarius</i>	Jay
<i>Emberiza calandra</i>	Corn bunting	<i>Luscinia megarhynchos</i>	Nightingale
<i>Emberiza citrinella</i>	Yellowhammer	<i>Musciapa striata</i>	Spotted flycatcher
<i>Emberiza schoeniclus</i>	Reed bunting	<i>Parus ater</i>	Coal tit
<i>Falco tinnunculus</i>	Kestrel	<i>Parus caeruleus</i>	Blue tit
<i>Motacilla flava</i>	Yellow wagtail	<i>Parus major</i>	Great tit
<i>Passer montanus</i>	Tree sparrow	<i>Parus palustris</i>	Marsh tit
<i>Perdix perdix</i>	Grey partridge	<i>Phylloscopus collybita</i>	Chiffchaff
<i>Streptopelia turtur</i>	Turtle dove	<i>Phylloscopus trochilus</i>	Willow warbler
<i>Sturnus vulgaris</i>	Starling	<i>Picus viridis</i>	Green woodpecker
<i>Sylvia communis</i>	Whitethroat	<i>Prunella modularis</i>	Dunnock
<i>Vanellus vanellus</i>	Lapwing	<i>Pyrrhula pyrrhula</i>	Bullfinch
<hr/>		<i>Regulus regulus</i>	Goldcrest
Wintering waterfowl		<i>Sitta europaea</i>	Nuthatch
<i>Anas acula</i>	Pintail	<i>Strix aluco</i>	Tawny owl
<i>Anas penelope</i>	Wigeon	<i>Sylvia atricapilla</i>	Blackcap
<i>Anas platyrhynchos</i>	Mallard	<i>Sylvia borin</i>	Garden warbler
<i>Anas strepera</i>	Gadwall	<i>Sylvia curruca</i>	Lesser whitethroat
<i>Anser answer</i>	Greylag goose	<i>Troglodytes troglodytes</i>	Wren
<i>Aythya farina</i>	Pochard	<i>Turdus merula</i>	Blackbird
<i>Aythya fuligula</i>	Tufted duck	<i>Turdus philomelos</i>	Song thrush
<i>Branta bernicula</i>	Brent goose		
<i>Branta leucopsis</i>	Barnacle goose		
<i>Cygnus olor</i>	Mute swan		
<i>Fulica atra</i>	Coot		
<i>Haematopus</i>	Oystercatcher		
<i>Limosa lapponica</i>	Bart-tailed godwit		
<i>Mergus merganser</i>	Goosander		
<i>Numenius arquatica</i>	Curlew		
<i>Phalacrocorax carbo</i>	Cormorant		
<i>Podiceps cristatus</i>	Great crested grebe		
<i>Podiceps ruficollis</i>	Little grebe		
<i>Tadorna tadorna</i>	Shelduck		
<i>Tringa totanus</i>	Redshank		

Appendix 4 Worked examples

Criterion	Barton Hills	Duck End	Kidney Wood	Knocking Hoe	Maulden Church Meadow	Maulden Wood
Vegetation						
Uniqueness of plant community type	5	5	0	5	5	0
Representativity: species composition vs a reference plant community type	4	2	2	4	3	3
Succession-disturbance degree: successional level, introduced and heliophyte species	5	2	1.4	5	2	1.4
Rarity: number of rare species	0.8	0	0	2.5	0	0
Richness: total number of species	5	5	0	5	5	2
Total vegetation value (/25)	19.8	14.0	3.4	21.5	15.0	6.4
Vegetation sensitivity rating	High	Low	Very low	Very high	High	Very low
Avifauna						
Uniqueness of wildlife habitat	2.4	3	3	1.9	1.7	3.3
Representativity (5 pts): bird community composition vs a reference bird community type	1.9	5	3.2	1.2	0.3	5
Rarity: number of rare species	1	1.7	0.3	1.4	0	2.4
Importance for wildlife: critical areas for life cycle	0	0	0	0	0	0
Total avifauna value (/20)	5.3	6.4	6.7	4.5	2.0	10.1
Avifauna sensitivity rating	Low	Low	Low	Very low	Very low	Low
Soil and land characteristics						
Drainage (6 pts)	0	0	0	0	0	0
Submersibility (6 pts)	0	0	0	0	0	0
Texture (6 pts)	3	6	3	3	0	3
Slope (3)	2	0	2	2	2	2
Total abiotic value (/21)	5	6	5	5	2	5
Abiotic sensitivity rating	Low	High	Low	Low	Very low	Low
OVERALL SENSITIVITY RATING	High	High	Low	Very high	High	Low

Barton Hills

Size: 44.5 ha/445,000 m²

Vegetation type(s): 14.5 ha wet woodland (WL); 30 ha calcareous grassland (GL)

Bird community: Farmland and Woodland

Vegetation:

Uniqueness of plant community type: Score: 5/5

The score for Barton Hills was based on its chalk grassland. Nationally it is estimated that 38,687 ha of lowland calcareous grassland exist in England, representing 2.2% of the country's BAP habitat. As it comprises <5% of the national BAP habitat area, chalk grassland has been classed as 'uncommon' at a national scale.

The 2007 Bedfordshire chalk grassland mapping project revealed 318 ha of lowland calcareous grassland in the county. This represents 4.77% of county BAP habitat, and 0.8% of the national chalk grassland total. The county habitat area can therefore also be considered as 'uncommon', and a representative proportion of the national total. This would normally yield a score of 2/5; however chalk grassland represents such a large proportion of Bedfordshire's BAP habitats it has been given a score of 5 for its local importance.

Representativity: Score: 4/5

As a NNR, Barton Hills scores a 4 on this scale.

Succession-disturbance degree: Score: 5/5

Chalk grassland scores 3 habitat points for its restoration time (1 point), number of associated rare species (1 point) and need for grazing (1 point).

Barton Hills scores an additional point for the presence of Pasqueflower, one of a list of 'sensitive' species with needs not met by standard habitat management practices. The soils of Barton Hills are ancient, and believed never to have been cultivated. The site therefore scores an additional point for its soil ecology.

Rarity: Score: 0.8/5

Two UK BAP vascular plant species have been recorded at Barton Hills. This represents 13.3% of UK BAP chalk grassland plant species found in Bedfordshire. Under the proposed scoring system, a site with 80% of possible BAP plant species scores the full 5 points. Therefore all scores must be converted to a figure /80 and then to the appropriate number of points.

Richness: Score: 5/5

203 vascular plant species have been recorded at Barton Hills. Dony's values of *c* (17.62) and *z* (0.181) for Bedfordshire's chalk grassland habitats were used in the species-area calculation, which yields a theoretical species richness of 186 vascular plant species for the site. Therefore more than the maximum theoretical number of species have been recorded at Barton Hills, resulting in a score of 5.

Avifauna:

Uniqueness of wildlife habitat: Score: 2.4/5

The 2km radius around Barton Hills is a mix of mainly pasture (approximately 70%) and developed area (i.e. the village of Barton-le-Clay). In this case a weighted average has been taken of the two landscape cost values (pasture: 10 and developed: 20). The result has been converted to a score out of five.

Representativity: Score: 2.6/5

While Barton Hills is primary chalk grassland and surrounded by farmland, most of the BTO indicator species recorded on the site are in fact woodland birds. Records for the site include 7 of the 27 woodland indicator species used in reporting for the East of England, and 3 of the 19 farmland indicator species. Converted to scores out of 5 (where 80% of the indicator species results in a full 5 points), these woodland and farmland scores would be 1.6 and 1.0 respectively. These two figures have been *added* together to yield a score of 2.6/5. Calculating a single score out of 46 (the total number of woodland and farmland indicator species) would have yielded a much lower score, one likely not representative of the site's value or habitats.

Rarity: Score: 1/5

Three BAP bird species have been recorded at Barton Hills. Of the 42 UK BAP bird species found in Bedfordshire, 18 are likely to be found in or around grassland habitats. The species recorded at Barton Hills therefore represent 17% of the potential BAP species for the site. As with some of the other measures, a site with 80% of the potential species range scores full marks. All scores must therefore include this calculation; in this case the result is 1.

Importance for wildlife: Score: 0/5

No critical life cycle areas are known to exist at Barton Hills.

Abiotic sensitivity:

Drainage: Score: 0/6

According to Soilsclapes Viewer, Barton Hills lies on 'shallow lime-rich soils over chalk or limestone', which are classed by the NSRI as 'freely draining'.

Submersibility: Score: 0/6

Barton Hills lies well outside a floodplain and accordingly is likely not to be flooded, or according to Lajeunesse et al, 'never submerged'.

Texture: Score: 3/6

Shallow lime-rich soils over chalk or limestone are classified by the NSRI as 'loamy'.

Slope: Score: 2/3

The steepest slope recorded at Barton Hills is 49% on the western side towards Sharpenhoe Clappers. Loamy soils with a slope >12% have been classified in the FEP manual as being at 'high' risk of erosion, yielding a score of 2.

Duck End

Size: 1.9 ha/19,000 m²

Vegetation type(s): lowland meadow

Bird community: farmland and woodland

Vegetation:

Uniqueness of plant community type: Score: 5/5

The score for Duck End was based on its lowland meadow. Nationally it is estimated that 7282 ha of lowland meadow exist in England, representing 0.4% of the country's BAP habitat. As it comprises <1% of the national BAP habitat area, lowland meadow has been classed as 'rare' at a national scale.

Last estimates indicate that there are approximately 50 ha of lowland meadow in the county. This represents 0.75% of county BAP habitat, and 0.7% of the national lowland meadow total. The habitat can therefore also be considered 'rare'. The local and national rarity yields a score of 5.

Representativity: Score: 2/5

As a County Wildlife Site, Duck End scores 2 points on this scale.

Succession-disturbance degree: Score: 2/5

Lowland meadow scores 2 habitat points for its restoration time (1 point), number of associated rare species (0.5 point) and facultative need for grazing (0.5 point).

There are no known 'sensitive' species at Duck End, nor is the site believed to have ancient soils.

Rarity: Score: 0/5

No UK BAP vascular plant species have been recorded at Duck End.

Richness: Score: 5/5

265 vascular plant species have been recorded at Duck End. Dony's values of c (6.1) and z (0.019) for Bedfordshire's neutral grassland habitats were used in the species-area calculation, which yields a theoretical species richness of 7 vascular plant species for the site, a figure which reflects the degraded state of most of Bedfordshire's meadows. Therefore more than the maximum theoretical number of species have been recorded at Duck End, resulting in a score of 5.

Avifauna:

Uniqueness of wildlife habitat: Score: 3/5

The 2km radius around Duck End is a mix of mainly arable crop production (approximately 80%) and developed area (i.e. the village of Maulden). In this case a weighted average has been taken of the two landscape cost values (arable crops: 10 and developed: 20). The result has been converted to a score out of five.

Representativity: Score: 1.7/5

Records for the site include 3 of the 27 woodland indicator species used in reporting for the East of England, and 3 of the 19 farmland indicator species. Converted to scores out of 5 (where 80% of the indicator species results in a full 5 points), these woodland and farmland scores would be 0.7 and 1.0 respectively. These two figures have been *added* together to yield a score of 1.7/5. Calculating a single score out of 46 (the total number of woodland and farmland indicator species) would have yielded a much lower score, one likely not representative of the site's value or habitats.

Rarity: Score: 1.7/5

Five BAP bird species have been recorded at Duck End. Of the 42 UK BAP bird species found in Bedfordshire, 18 are likely to be found in or around grassland habitats. The species recorded at Duck End therefore represent 28% of the potential BAP species for the site. As with some of the other measures, a site with 80% of the potential species range scores full marks. All scores must therefore include this calculation; in this case the result is 1.7.

Importance for wildlife: Score: 0/5

No critical life cycle areas are known to exist at Barton Hills.

Abiotic sensitivity:

Drainage: Score: 0/6

According to Soilsclapes Viewer, Duck End lies on 'lime-rich loamy and clayey soils with impeded drainage', which are classed by the NSRI as having 'slightly impeded drainage'.

Submersibility: Score: 0/6

Duck End lies well outside the floodplain of the River Flit. However part of the site is submerged for at least part of the year. A judgement call would be needed in this case as the score could be 3/6 instead.

Texture: Score: 6/6

Lime-rich loamy and clayey soils with impeded drainage are classified by the NSRI as 'clayey'.

Slope: Score: 0/3

The steepest slope recorded at Duck End is 1.7%. The site is essentially flat.

Kidney Wood

Size: 6.8 ha/68,000 m²

Vegetation type(s): lowland mixed deciduous woodland

Bird community: woodland

Vegetation:

Uniqueness of plant community type:

Score: 0/5

Nationally it is estimated that 400,224 ha of lowland woodland exist in England, representing 22.7% of the country's BAP habitat. As mentioned above, this has been classed as 'common' at a national scale.

Last estimates indicate that there are approximately 5216 ha of woodland in the county. This represents 79% of county BAP habitat, and 1.3% of the national total. The county habitat area can therefore also be considered as 'common', and a more or less representative proportion of the national total.

Representativity:

Score: 2/5

As a County Wildlife Site, Kidney Wood scores 2 points on this scale.

Succession-disturbance degree:

Woodland scores 1.4 habitat points for its restoration time (1 point), number of associated rare species (0.4 point) and need for grazing (0 points).

There are no known 'sensitive' species at Kidney Wood, nor is the site believed to have ancient soils.

Rarity:

Score: 0/5

No UK BAP vascular plant species have been recorded at Kidney Wood.

Richness:

Score: 0/5

192 vascular plant species have been recorded at Kidney Wood. Dony's values of *c* (4.86) and *z* (0.463) for Bedfordshire's woodlands were used in the species-area calculation, which yields a theoretical species richness of 840 vascular plant species for the site. However Bedfordshire is home to approximately only 500 plant species, the maximum which could be expected to be found on the site. Therefore 38% of the theoretical number of species have been recorded at Kidney Wood, resulting in a score of 0.

Avifauna:

Uniqueness of wildlife habitat:

Score: 3/5

The 2km radius around Kidney Wood is a mix of approximately 50% permanent pasture with mature trees (Luton Hoo) and 50% developed area (i.e. Luton). In this case a weighted average has been taken of the two landscape cost values (permanent pasture with mature trees: 4 and developed: 20). The result has been converted to a score out of five.

Representativity: Score: 3.4/5

Records for the site include 12 of the 27 woodland indicator species used in reporting for the East of England, and 2 of the 19 farmland indicator species. Converted to scores out of 5 (where 80% of the indicator species results in a full 5 points), these woodland and farmland scores would be 2.8 and 0.7 respectively. These two figures have been *added* together to yield a score of 3.4/5 (includes rounding error). Calculating a single score out of 46 (the total number of woodland and farmland indicator species) would have yielded a much lower score, one likely not representative of the site's value or habitats.

Rarity: Score: 0.3/5

One BAP bird species have been recorded at Kidney Wood. Of the 42 UK BAP bird species found in Bedfordshire, 21 are likely to be found in or around woodland habitats. The species recorded at Kidney Wood therefore represents 5% of the potential BAP species for the site. As with some of the other measures, a site with 80% of the potential species range scores full marks. All scores must therefore include this calculation; in this case the result is 0.3.

Importance for wildlife: Score: 0/5

No critical life cycle areas are known to exist at Kidney Wood.

Abiotic sensitivity:

Drainage: Score: 0/6

According to Soilsclapes Viewer, Kidney Wood lies on 'slightly acid loamy and clayey soils with impeded drainage, which are classed by the NSRI as having 'slightly impeded drainage'.

Submersibility: Score: 0/6

Kidney Wood lies outside a floodplain on the edge of an urban area and is therefore unlikely to flood.

Texture: Score: 3/6

Slightly acid loamy and clayey soils with impeded drainage are classified by the NSRI as 'loamy'.

Slope: Score: 2/3

The steepest slope recorded at Kidney Wood is 17%. Loamy soils with a slope >12% have been classified in the FEP manual as being at 'high' risk of erosion, yielding a score of 2.

Knocking Hoe

Size: 8.4 ha/84,000 m²

Vegetation type(s): calcareous grassland (GL)

Bird community: Farmland

Vegetation:

Uniqueness of plant community type: Score: 5/5

The score for Knocking Hoe was based on its chalk grassland. Nationally it is estimated that 38,687 ha of lowland calcareous grassland exist in England, representing 2.2% of the country's BAP habitat. As it comprises <5% of the national BAP habitat area, chalk grassland has been classed as 'uncommon' at a national scale.

The 2007 Bedfordshire chalk grassland mapping project revealed 318 ha of lowland calcareous grassland in the county. This represents 4.77% of county BAP habitat, and 0.8% of the national chalk grassland total. The county habitat area can therefore also be considered as 'uncommon', and a representative proportion of the national total. This would normally yield a score of 2/5; however chalk grassland represents such a large proportion of Bedfordshire's BAP habitats it has been given a score of 5 for its local importance.

Representativity: Score: 4/5

As a National Nature Reserve, Knocking Hoe scores a 4 on this scale.

Succession-disturbance degree: Score: 5/5

Chalk grassland scores 3 habitat points for its restoration time (1 point), number of associated rare species (1 point) and need for grazing (1 point).

Knocking Hoe scores an additional point for the presence of Pasqueflower, one of a list of 'sensitive' species with needs not met by standard habitat management practices. The soils of Knocking Hoe are ancient, and believed never to have been cultivated. The site therefore scores an additional point for its soil ecology.

Rarity: Score: 2.5/5

Six UK BAP vascular plant species have been recorded at Knocking Hoe. This represents 40% of UK BAP chalk grassland plant species found in Bedfordshire. Under the proposed scoring system, a site with 80% of possible BAP plant species scores the full 5 points. Therefore all scores must be converted to a figure /80 and then to the appropriate number of points.

Richness: Score: 5/5

222 vascular plant species have been recorded at Knocking Hoe. Dony's values of c (17.62) and z (0.181) for Bedfordshire's chalk grassland habitats were used in the species-area calculation, which yields a theoretical species richness of 137 vascular plant species for the site. Therefore more than the maximum theoretical number of species have been recorded at Knocking Hoe, resulting in a score of 5.

Avifauna:

Uniqueness of wildlife habitat: Score: 1.9/5

The 2km radius around Knocking Hoe is a mix of approximately 50% permanent pasture and meadow and 50% cultivated crops. In this case a weighted average has been taken of the two landscape cost values (permanent pasture and meadow: 5 and cultivated crops: 10). The result has been converted to a score out of five.

Representativity: Score: 1.2/5

Records for the site include 1 of the 27 woodland indicator species used in reporting for the East of England, and 3 of the 19 farmland indicator species. Converted to scores out of 5 (where 80% of the indicator species results in a full 5 points), these woodland and farmland scores would be 0.2 and 1.0 respectively. These two figures have been *added* together to yield a score of 1.2/5. Calculating a single score out of 46 (the total number of woodland and farmland indicator species) would have yielded a much lower score, one likely not representative of the site's value or habitats.

Rarity: Score: 1.4/5

Four BAP bird species have been recorded at Knocking Hoe. Of the 42 UK BAP bird species found in Bedfordshire, 18 are likely to be found in or around grassland habitats. The species recorded at Knocking Hoe therefore represent 22% of the potential BAP species for the site. As with some of the other measures, a site with 80% of the potential species range scores full marks. All scores must therefore include this calculation; in this case the result is 1.4.

Importance for wildlife: Score: 0/5

No critical life cycle areas are known to exist at Knocking Hoe.

Abiotic sensitivity:

Drainage: Score: 0/6

According to Soilscales Viewer, Knocking Hoe lies on 'shallow lime-rich soils over chalk or limestone', which are classed by the NSRI as 'freely draining'.

Submersibility: Score: 0/6

Knocking Hoe lies well outside a floodplain and accordingly is likely not to be flooded, or according to Lajeunesse et al, 'never submerged'.

Texture: Score: 3/6

Shallow lime-rich soils over chalk or limestone are classified by the NSRI as 'loamy'.

Slope: Score: 0/3

The steepest slope recorded at Knocking Hoe is 27%. Loamy soils with a slope >12% have been classified in the FEP manual as being at 'high' risk of erosion, yielding a score of 2.

Maulden Church Meadow

Size: 3.3 ha/33,000 m²

Vegetation type(s): lowland meadow (GL)

Bird community: Farmland and Woodland

Vegetation:

Uniqueness of plant community type: Score: 5/5

The score for Maulden Church Meadow was based on its lowland meadow. Nationally it is estimated that 7282 ha of lowland meadow exist in England, representing 0.4% of the country's BAP habitat. As it comprises <1% of the national BAP habitat area, lowland meadow has been classed as 'rare' at a national scale.

Last estimates indicate that there are approximately 50 ha of lowland meadow in the county. This represents 0.75% of county BAP habitat, and 0.7% of the national lowland meadow total. The habitat can therefore also be considered 'rare'. The local and national rarity yields a score of 5.

Representativity: Score: 3/5

As a Site of Special Scientific Interest, Maulden Church Meadow scores a 3 on this scale.

Succession-disturbance degree: Score: 2/5

Lowland meadow scores 2 habitat points for its restoration time (1 point), number of associated rare species (0.5 point) and facultative need for grazing (0.5 point).

There are no known 'sensitive' species at Maulden Church Meadow, nor is the site believed to have ancient soils.

Rarity: Score: 0/5

No UK BAP vascular plant species have been recorded at Maulden Church Meadow.

Richness: Score: 5/5

134 vascular plant species have been recorded at Maulden Church Meadow. Dony's values of c (6.1) and z (0.019) for Bedfordshire's neutral grassland habitats were used in the species-area calculation, which yields a theoretical species richness of 7 vascular plant species for the site, a figure which reflects the degraded state of most of Bedfordshire's meadows. Therefore more than the maximum theoretical number of species have been recorded at Maulden Church Meadow, resulting in a score of 5.

Avifauna:

Uniqueness of wildlife habitat: Score: 1.8/5

The 2km radius around Maulden Church Meadow is a mix of approximately 50% woodland and cultivated crops. In this case a weighted average has been taken of the two landscape cost values (mixed woodland: 2 and cultivated crops: 10). The result has been converted to a score out of five.

Representativity: Score: 0.3/5

Records for the site include 0 of the 27 woodland indicator species used in reporting for the East of England, and 1 of the 19 farmland indicator species. Converted to scores out of 5 (where 80% of the indicator species results in a full 5 points), these woodland and farmland scores would be 0 and 0.3 respectively. These two figures have been *added* together to yield a score of 0.3/5. Calculating a single score out of 46 (the total number of woodland and farmland indicator species) would have yielded a much lower score, one likely not representative of the site's value or habitats.

Rarity: Score: 0/5

No UK BAP bird species have been recorded at Maulden Church Meadow.

Importance for wildlife: Score: 0.5

No critical life cycle areas are known to exist at Maulden Church Meadow.

Abiotic sensitivity:

Drainage: Score: 0/6

According to Soilsmap Viewer, Maulden Church Meadow lies on 'freely draining slightly acid sandy soils', which are classed by the NSRI as 'freely draining'.

Submersibility: Score: 0/6

Maulden Church Meadow lies well outside a floodplain and accordingly is likely not to be flooded, or according to Lajeunesse et al, 'never submerged'.

Texture: Score: 0/6

Freely draining slightly acid sandy soils are classified by the NSRI as 'sandy'.

Slope: Score: 2/3

The steepest slope recorded at Maulden Church Meadow is 10%. Sandy soils with a slope between 5 and 12% have been classified in the FEP manual as being at 'high' risk of erosion, yielding a score of 2.

Maulden Wood

Size: 148.3 ha/1,483,000 m²

Vegetation type(s): woodland (WL)

Bird community: Woodland

Vegetation:

Uniqueness of plant community type: Score: 0/5

Nationally it is estimated that 400,224 ha of lowland woodland exist in England, representing 22.7% of the country's BAP habitat. As mentioned above, this has been classed as 'common' at a national scale.

Last estimates indicate that there are approximately 5216 ha of woodland in the county. This represents 79% of county BAP habitat, and 1.3% of the national total. The county habitat area can therefore also be considered as 'common', and a more or less representative proportion of the national total.

Representativity: Score: 3/5

As a SSSI, Maulden Wood scores a 3 on this scale.

Succession-disturbance degree: Score: 1.4/5

Woodland scores 1.4 habitat points for its restoration time (1 point), number of associated rare species (0.4 point) and need for grazing (0 points).

There are no known 'sensitive' species at Maulden Wood. The site is a recognised Plantation on Ancient Woodland Site (PAWS) and therefore has altered soil ecology.

Rarity: Score: 0/5

No UK BAP vascular plant species have been recorded at Maulden Wood.

Richness: Score: 2/5

273 vascular plant species have been recorded at Maulden Wood. Dony's values of *c* (4.86) and *z* (0.463) for Bedfordshire's woodlands were used in the species-area calculation, which yields a theoretical species richness of 3501 vascular plant species for the site. However Bedfordshire is home to approximately only 500 plant species, the maximum which could be expected to be found on the site. Therefore 55% of the theoretical number of species have been recorded at Maulden Wood, resulting in a score of 2.

Avifauna:

Uniqueness of wildlife habitat: Score: 3.3/5

The 2km radius around Maulden Wood is a mix of mainly cultivated crops (70%) and urban (i.e. the village of Maulden). In this case a weighted average has been taken of the two landscape cost values (cultivated crops: 10 and urban: 20). The result has been converted to a score out of five.

Representativity: Score: 4.5/5

Records for the site include 18 of the 27 woodland indicator species used in reporting for the East of England, and 1 of the 19 farmland indicator species. Converted to scores out of 5 (where 80% of the indicator species results in a full 5 points), these woodland and farmland scores would be 4.2 and 0.3 respectively. These two figures have been *added* together to yield a score of 4.5/5. Calculating a single score out of 46 (the total number of woodland and farmland indicator species) would have yielded a much lower score, one likely not representative of the site's value or habitats.

Rarity: Score: 2.4/5

Eight BAP bird species have been recorded at Maulden Wood. Of the 42 UK BAP bird species found in Bedfordshire, 21 are likely to be found in or around woodland habitats. The species recorded at Maulden Wood therefore represent 38% of the potential BAP species for the site. As with some of the other measures, a site with 80% of the potential species range scores full marks. All scores must therefore include this calculation; in this case the result is 2.4.

Importance for wildlife: Score: 0/5

No critical life cycle areas are known to exist at Maulden Wood.

Abiotic sensitivity:

Drainage: Score: 0/6

According to Soilsclapes Viewer, Maulden Wood lies on two soil types. The main soil type is 'slightly acid loamy and clayey soils with impeded drainage', which are classed by the NSRI as having 'slightly impeded drainage'

Submersibility: Score: 0/6

Maulden Wood lies well outside a floodplain at the top of the Greensand Ridge and accordingly is likely not to be flooded, or according to Lajeunesse et al, 'never submerged'.

Texture: Score: 3/6

Slightly acid loamy and clayey soils with impeded drainage are classified by the NSRI as 'loamy'.

Slope: Score: 2/3

The steepest slope recorded at Maulden Wood is 23%. Loamy soils with a slope >12% have been classified in the FEP manual as being at 'high' risk of erosion, yielding a score of 2.