Outline Habitat Suitability Index for the European Hedgehog – provisional model

Mark C Smith

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Outline Habitat Suitability Index for the European Hedgehog (*Erinaceus europeaus*) in Great Britain

1. Introduction

The Common Hedgehog (*Erniaceus europeaus*) is one of Britain's most well known mammals. Alongside the Grey Squirrel (*Sciurus carolinensis*) it is perhaps one the few species that people see with some regularity and interact with.

It is estimated that there are 1,100,000 hedgehogs in England with a further 145,000 in Wales and 310,000 in Scotland (Battersby, 2005) and (Harris & Yalden, 2008). There is mounting evidence that the species has been in decline since the 1960's (Hof, 2009).

To enable the assessment of a species viability in an area the United States Fish and Wildlife Service (USFWS) developed in 1980 the use of Habitat Suitability Indexes (HSI) for key species to determine how good particular habitats are at supporting the species with a view to improving population numbers or preserving key habitats. To date the USFWS have created HSI's for over 142 species (US Fish and Wildlife Service, 1980).

To date this approach has been applied to one species, the Great Crested Newt (*Triturus cristatus*) in the UK. Established in 2000 this HSI was designed to help focus the conservation of habitats necessary for this species survival (Oldham, Keeble, Swan, & Jeffcote, 2000). It is hoped that this same technique can be applied to other British species and in this case the European Hedgehog.

1.1 Developing a model

The index presented in this report is not to be regarded as a finished project. It is an outline procedure using available information collated from current literature. It offers one approach to the problem of assessing Habitat Suitability for the Hedgehog. It is hoped that this index serves as a secure groundwork for further work and refinement. All models need rigorous testing and trialling in the field to test their efficacy.

2. Designing the Model

2.1 Model Objectives

This models ideal output is a value between 0 and 1.0 with a linear relationship to carrying capacity. It is aimed to represent the various species metrics that effect the distribution and density of the species (US Fish and Wildlife Service, 1980).

2.2 Creating the model

The model was created from an extensive literature review that was used to identify a range of variables that are likely to have a direct influence on the distribution and density of hedgehogs. Where possible the most up to data information has been used.

These variables must:

a) Relate to the carrying capacity
b) Indicate a known relationship
c) Be practical to measure

(US Fish and Wildlife Service, 1980)

The variables were identified to represent aspects such as:

a) Life Requisites
b) Seasonal Habitat/Usage/Behaviour
c) Life Stages
d) Biological/Physical/Chemical Characters (i.e. Cover Type)

(US Fish and Wildlife Service, 1980)

The constructed model must be documented (see Section 3) and then tested. (US Fish and Wildlife Service, 1980).

2.3 Uses and Limitations

This methodology is only useful in evaluating the suitability of an area for Hedgehogs which could be used as the basis for identifying management priorities or the species. The model should not be used as a substitute for direct count methodologies for establishing population levels.

It should be understood that the values used are relative and not absolute. Further study and refinement is required.

3. The Habitat Suitability Model for the European Hedgehog

3.1 Information

3.1.1 General

The European Hedgehog (*Erinaceus europeaus*) is the only member of the order Erinaceomorpha in Britain (Harris & Yalden, 2008). The species evolved at the end of the Cretaceous and became distinct in the Oligocene (Reeve, 1994). It was present in Great Britain since the Mesolithic (Harris & Yalden, 2008).

The species is widespread throughout Europe and west into Asian Russia (Morris, 2010). There is a population of introduced Hedgehogs in New Zealand (Morris, 2010).

Described as a generalist insectivore, individuals weigh on average 1.5 kg (Reeve, 1994). Their distinctive feature is a covering of modified hairs that form spines on the back (Reeve, 1994) (Morris, 2010) which when the animal rolls up provides a considerable defence against predation.

Hedgehogs are dormant during the winter and hibernate from November to March (Morris, 2010).

3.1.2 Food

Hedgehogs are predominantly generalist insectivores preying upon ground invertebrates (Harris & Yalden, 2008). 75% of the diet is composed of beetles of which 60% are carabids (Morris, 2010). Earthworms can form up to 50% of the hedgehog's diet and caterpillar and slugs are also commonly taken (Morris, 2010). In smaller numbers other invertebrates such as woodlice and millipedes form part of the diet but there is a general preference for soft bodied prey (Reeve, 1994).

Studies have shown that Hedgehogs are far from exclusive invertebrate feeders they have been recorded eating the nestlings of mice and voles, frogs, eggs and carrion (Morris, 2010).

3.1.3 Habitat

Hedgehogs are prevalent in virtually all lowland habitats and are most abundant in a mosaic of grassland, woodland and scrub (Harris & Yalden, 2008) and especially woodland edge habitats (Hof, 2009). Hedges are particularly valuable landscape features acting as foraging territory and corridors for movement and dispersal (Reeve, 1994) (Hof, 2009).

Farmland, particularly arable land is much less suitable for hedgehogs and is rarely selected for. They are also scarce where the soil is poor or there is little cover in habitats such as coniferous woodland, marshland or moorland (Reeve, 1994) (Harris & Yalden, 2008) (Hof, 2009).

Hedgehogs have adapted well to urban and semi-urban habitats. They use several gardens for foraging and prefer untidy ones with some grass and cover (Morris, 2010).

3.1.4 Reproduction

The hedgehog breeding season runs from mid-may up until September with two peaks of pregnancies, one in May/July and the other in September (Reeve, 1994) (Harris & Yalden, 2008).

Hedgehogs become sexually mature in their second year (Reeve, 1994). In the breeding season males will seek out and mate with females but pair bonds are not maintained (Reeve, 1994) (Morris, 2010). The female will gestate for 31-35 days before giving birth to between 4-5 hoglets in a summer nest.

Hoglets leave the nest after 22 days after which they stay close to their mother before dispersing 4-6 weeks later (Harris & Yalden, 2008).

3.1.5 Interspersion

Hedgehogs tend to be solitary animals. They maintain a flexible home-range which is sexually defined. Male hedgehogs roam in areas up to 60 acres with females using roughly half this size (Reeve, 1994). Home-ranges although marked by faeces and scent marking are not usually defended. Although not territorial, hedgehogs can be aggressive when dominant males come into contact or sows are with young (Morris, 2010).

There is little evidence to juvenile dispersal range but it is believed to be small leading to populations expanding slowly (Harris & Yalden, 2008).

3.1.6 Mortality

Due to the structural and behavioural adaptations of the hedgehog few species are able to catch and eat them. Foxes (*Vulpes vulpes*), cats and dogs can all injure Hedgehogs but lack the strength

to unroll one or break through the spines. Hedgehogs taken by these species are either injured, diseased or taken as carrion (Hof, 2009).

Badgers (*Meles meles*) are the greatest predation risk. They are strong enough to unroll a hedgehog and where Badger density exceeds 20 individuals per km^2 hedgehogs can become locally extinct (Harris & Yalden, 2008) (Hof, 2009) (Morris, 2010).

Other sources of predation can include Tawny Owls (*Strix aluco*), Polecats (*Mustela putorius*) and Otters (*Lutra lutra*). Hedgehog nestlings are particularly vulnerable to predation by Rats (*Rattus norvegicus*) and Stoats (*Mustela erminea*) (Reeve, 1994) (Morris, 2010).

In urban areas the Hedgehog is vulnerable to strimmers and bonfires that may disturb summer nests of hibernacula (Cresswell, et al., 2012). Hedgehogs are capable swimmers but are at risk of drowning in ponds without exit points (Morris, 2010).

Poisoning has long been a problem for sub-urban hedgehogs and those in arable habitats. Recent studies have shown that meta-aldehyde slug pellets are unlikely to be eaten in sufficient doses to prove deadly (Morris, 2010); they do however accumulate in liver and fat cells reducing overall fitness (Reeve, 1994). Other pesticides such as HCB's, HCH's, HLE's, DDE's and PCB's are likely to have a similar effect.

Roads are often seen as the greatest cause of mortality in hedgehogs mainly due to the fact that people see so many dead on the roadside however the reality is more complex. Roads can reduce hedgehog densities by 30% (Cresswell, et al., 2012) and 8.8% of all injuries to hedgehogs brought to rescue centres are as a result of road traffic accidents (Harris & Yalden, 2008).

Peak mortality on roads is between April and September (Arnold, 1993). Most male casualties occur early in the season with female casualty rates increasing post-pregnancy when they are able to resume foraging (Reeve, 1994). It is noted that since the 1990's the number of hedgehogs killed per 100 miles is down by 20-30% (Harris & Yalden, 2008). This could correlate to a general decline in the species however, rather than roads becoming less of a danger.

Not all road or times of day present the same level of hazard. Busy roads during the day can be silent at night (Rautio, 2014). Work by Hof (2009) indicates using General Linear Model regression that minor roads have a minor positive effect on hedgehog density perhaps as a result of the verge of hedgerow and major roads to have a minor negative effect on density.

Given the hedgehogs preference for linear corridors and their avoidance of large open spaces it can be concluded that major highways such as motorways present more of a barrier to dispersal than risk to mortality (Hof, 2009).

3.2 Model Applicability

3.2.1 Geographical

The model described in this report has been designed to be used in mainland Britain.

3.2.2 Seasonality

The model can be applied to any season although the accurate assessment of the habitat may need to be conducted in the spring or summer.

3.2.3 Cover Type

The model is developed to apply to any UK habitat covered by the JNCC Phase 1 Surveying technique (JNCC, 2010). It is more valid to lowland Britain.

3.2.4 Minimum Habitat Area

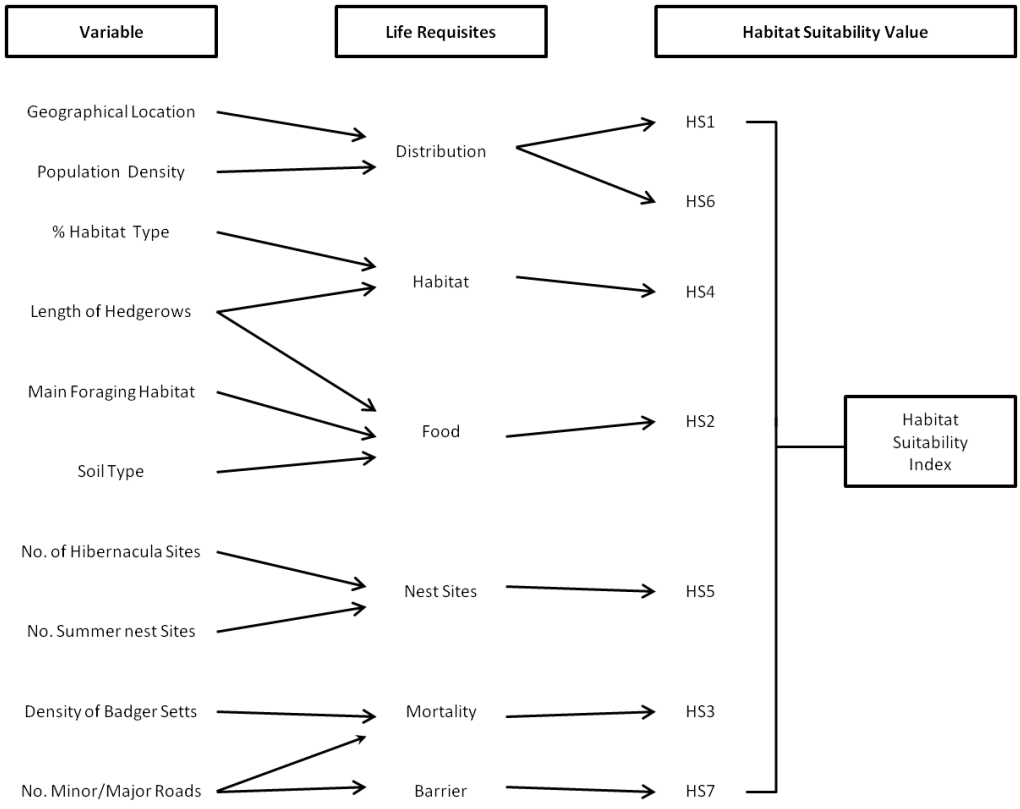
The minimum habitat area for hedgehogs is established to be approximately 1 hectare (Cresswell, et al., 2012) and the minimum viable population size to be between 0.9 and 2.4 km^2 (Moorhouse, 2013).

In this model the default scale for analysis is 1 km^2. This was chosen as an appropriate scale for habitat assessment.

3.3 Model Description

The HSI for the European Hedgehog considers the following factors to be important life requisites; Distribution, Habitat, Food, Availability of Nest Sites, Mortality risk and Barriers to dispersal.

These requisites are described by a series of variables that combine to form a cumulative Habitat Suitability Value.

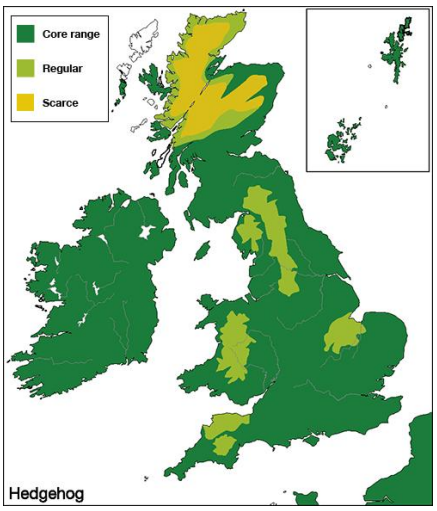


3.4 Model Relationships

Variable 1 Geographic Distribution HS1

UK Applicability

Habitat Suitability for HS1 is based on a distribution map included in Harris and Yaldens (2008) Mammals of the British Isles.



(Mammal Society)

The map indicates regular or usual range, scattered, rare and scarce regions. These values equate to the following HS values

$HS1^{UK}$

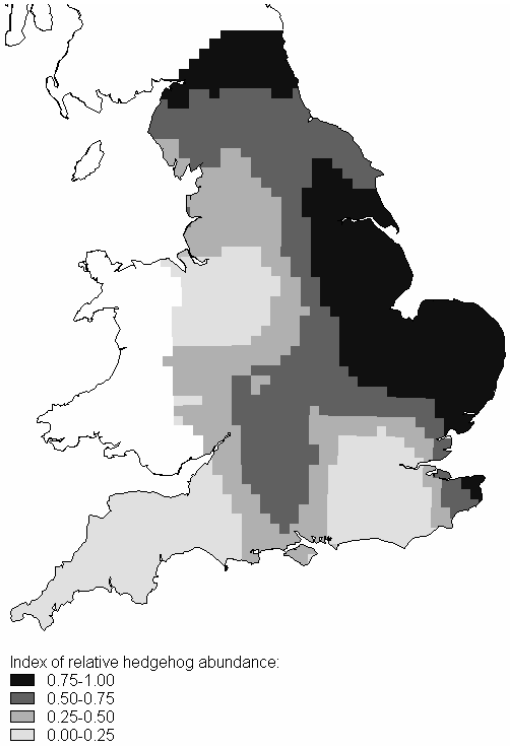
	HS Value
Regular/Usual	1.00
Rare	0.50
Scarce	0.01

Therefore $HS1^{UK}$ will vary between 0.01 and 1.00

Notable Issues: Are the assigned HS values representative? Should the rare value be significantly lower?

England-Only Applicability

Habitat suitability in this case is based on the distribution map developed by Hof (2009) using data from the HogWatch Survey based upon presence/absence data on a 10 km^2.



(Hof, 2009)

$HS1^{E}$

Abundance	HS Value
0.75-1.00	1.00
0.50-0.75	0.75
0.25-0.50	0.50
0.00-0.25	0.25

Therefore $HS1^{E}$ will vary between 0.025 and 1.00.

Notable Issues: Only applicable to England, data for Wales and Scotland missing.

Use

Use either $HS1^{UK}$ or $HS1^{E}$, or for England combine the two:

$$\frac{HS1^{UK} + HS1^{E}}{2} = HS1$$

HS1 is a mechanistic and spatially based variable.

Variable 2 Food HS2

This Habitat Suitability Index value is based on two foraging behaviour and habitat, and prey availability. Data is derived from work by Hof (2009) looking at the time spent foraging in particular habitats. It is expected that hedgehogs spend more time foraging in good habitats than in poor one. However it should be noted that where only poor habitats are present foraging

times could be significantly longer as hedgehogs need to forage for longer to gain the same level of nutrition.

$HS2^F$

Score for Primary Habitat. Primary Habitat is defined as the most common habitat type within the survey. The HS value is calculated from the table below with any modifiers added.

Primary Habitat	HS Value
Amenity Grassland	0.65
Arable land	0.35
Arable land with agri-environmental margins	0.45
Pasture	0.60
Set-aside	0.35
Village/Urban Area	0.45
Woodland	0.20

Modifiers:

+0.1 if hedges are present
+0.2 if small woodlands are present

Therefore $HS2^F$ will vary between 0.20 and 0.95

$HS2^S$

Invertebrate availability is a function of soil type. Different soil types affect the availability of many invertebrate species (Cresswell, et al., 2012). This part of the HS value is a direct reference to soil type.

Soil Type	HS Value
Dry/Sandy	0.01
Upland Acidic	0.01
Moist/Rich	1.00

Therefore $HS2^S$ will vary between 0.01 and 1.00.

The two variables are then combined to create an overall value for HS2

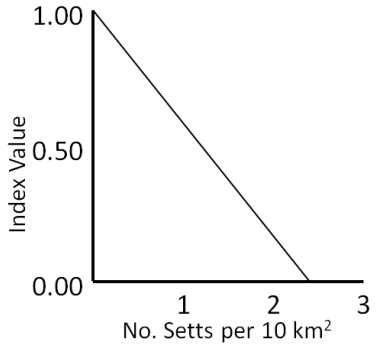
$$\frac{HS2^F + HS2^S}{2} = HS2$$

HS2 is a mechanistic and compensatory based variable.

Variable 3 Predation HS3

Hedgehog predation is dominated by the effect Badgers have on their density (Harris & Yalden, 2008) (Hof, 2009) (Reeve, 1994) (Morris, 2010). Other predators are deemed to have less of an effect on population.

There is a proportional relationship between badger density and hedgehog density therefore a graph based on sett density is used as established in work by Reeve (1994), Hof (2009) and Morris (2010).



Therefore HS3 will vary between 0.00 and 1.00.

HS1 is a mechanistic based variable.

Variable 4 Habitat HS4

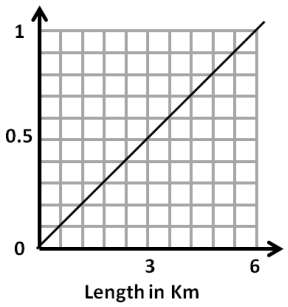
A range of habitats is used by the species with varying success. This variable assesses, on a 1 km^2 basis, the percentage of each habitat expressed as a decimal.

Using JNCC Phase 1 habitat criteria calculate the percentage coverage of habitat type's a to g and then use the graphs provided to calculate a HS value for each habitat.

Habitat	Habitat Reference	JNCC Code
$HS4^a$	Amenity Grassland	J1.2
$HS4^b$	Semi-Improved Grassland	B1-B3
$HS4^c$	Improved Grassland	B4
$HS4^d$	Arable	J1.1
$HS4^e$	Gardens	J1.3/J1.4
$HS4^f$	Mixed/Deciduous Woodland	A1.1, A1.3 and A3
$HS4^g$	Shrub/Scrub	A2

$HS4^h$

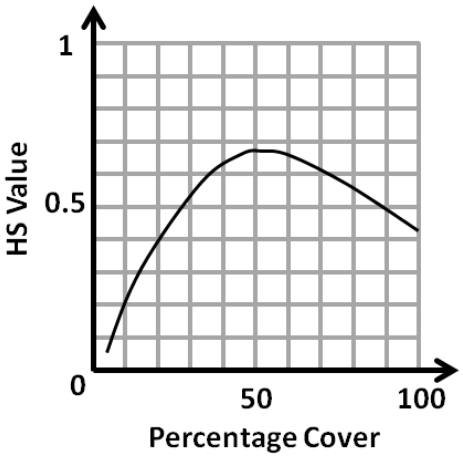
Hedgerows are particularly important habitats for hedgehogs and so the longer the lengths of hedgerows the better the habitat. The HS value is derived by measuring the total length of hedges in a 1 Km^2 from the graph below.



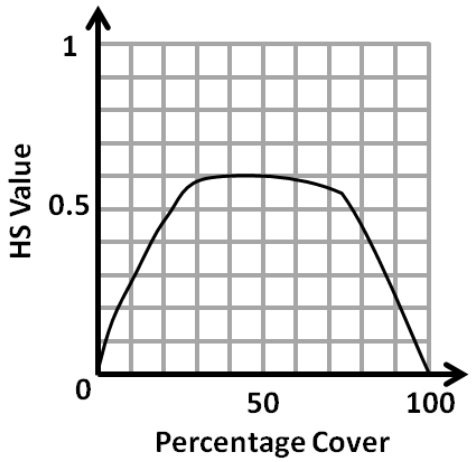
HS4 is then calculated by inputting the values into the following formula

$$\frac{(\sum HS4^{a}+\ldots HS4^{g})+(HS4^{h})}{n_{HS4^{a}\ldots HS4^{g}}+1}=HS4$$

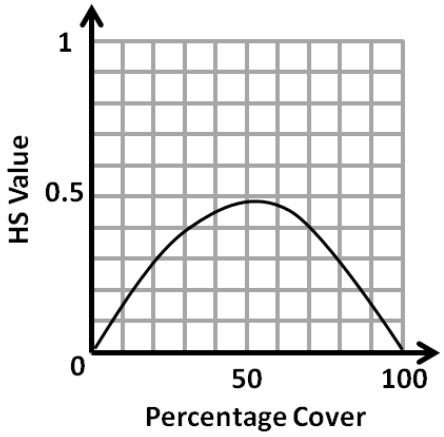
Therefore HS4 will vary from 0.00 to 1.00.



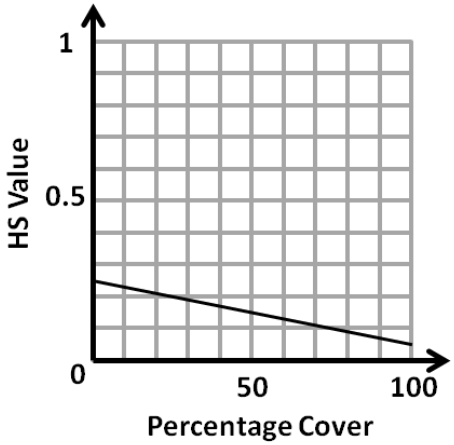
a) Amenity Grassland



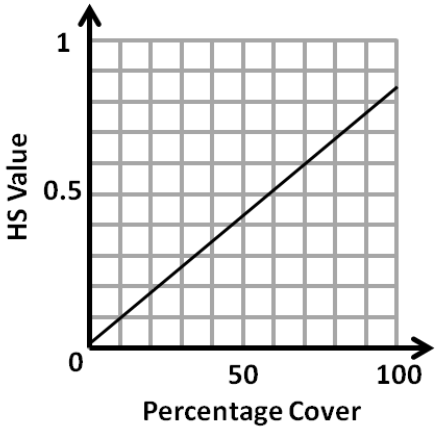
b) Semi-Improved Grassland



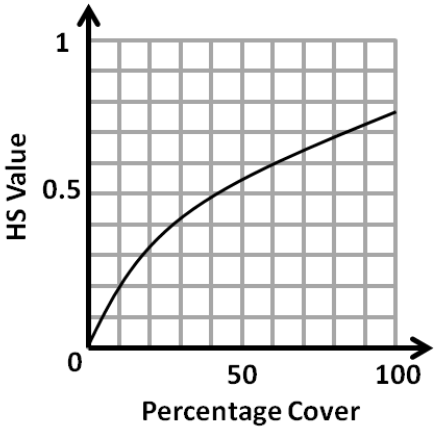
c) Improved Grassland



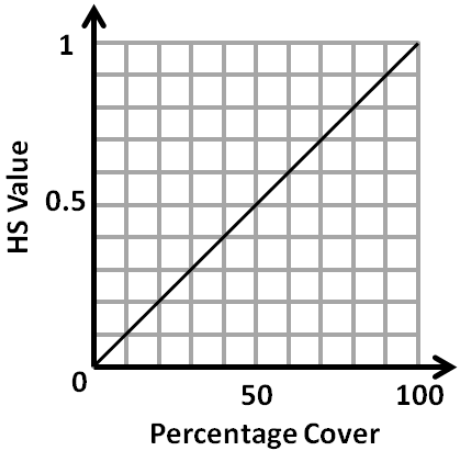
d) Arable



e) Garden



f) Woodland



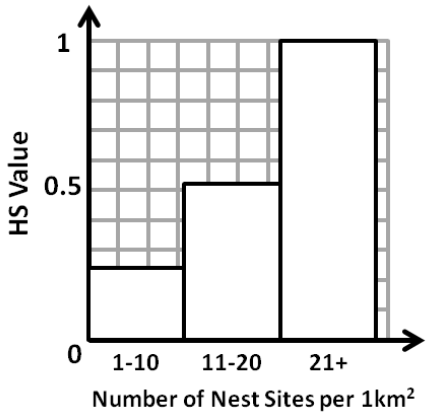
g) Shrub and Scrub

HS4 is a mechanistic, cumulative relationship and spatially based variable.

Variable 5 Nesting and Hibernacula HS5

Hedgehogs rely on two types of nest, hibernacula for hibernation and summer nests. Suitable nest sites are deemed to be:
-Under low Brambles/clumped vegetation
-Woodpiles
-Loose leaves
-Hollow stumps

$HS5^{W}$
HS value is based on the number of suitable nest sites available per 1 km^2.



$HS5^{SU}$

The variable for summer nests is based upon work by Hof (2009) and covers basic habitat types.

Primary Habitat	HS Value
a) Amenity Grassland	0.10
b) Arable land	0.30
c) Agri-environmental margins	0.20
d) Pasture	0.30
e) Set-aside	0.20
f) Village/Urban Area	0.15
i) Woodland	0.50
j) Hedges	0.60

$$\frac{\sum HS5^{a} \ldots HS4^{j}}{n} = HS5^{SU}$$

Notable Issues: Do these values need weighting?

HS5 is calculated by adding $HS5^{W}$ and $HS5^{SU}$ and dividing by 2.

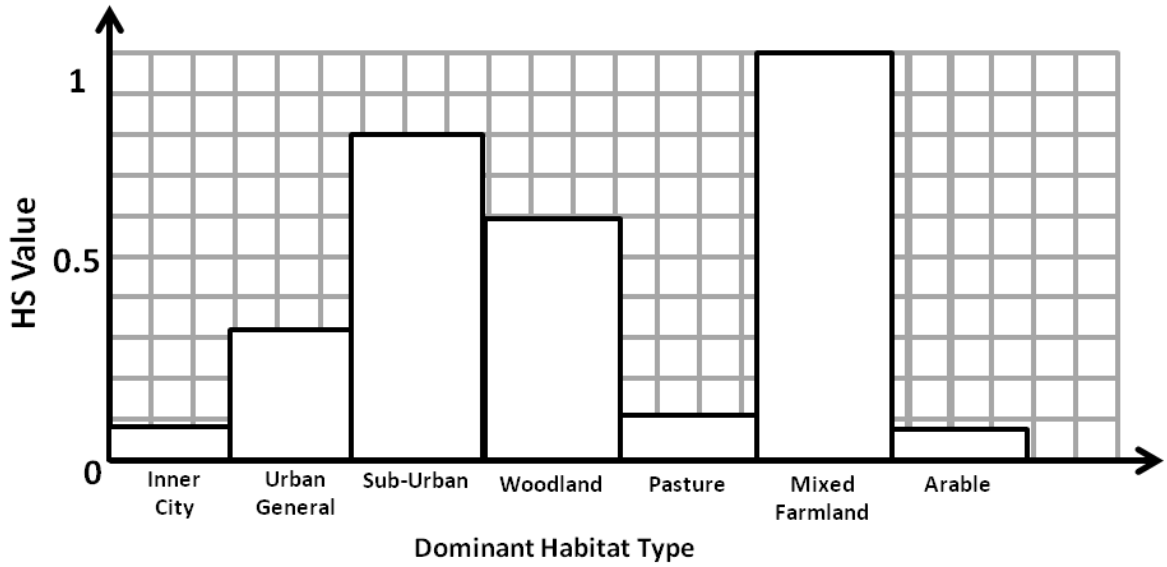
$$\frac{\sum HS5^{W} + HS5^{SU}}{2} = HS5$$

Therefore HS5 will vary from 0 to 1.00.

HS1 is a mechanistic and cumulative based variable.

Variable 6 Population Density HS6

Population Density in this model is expressed as a function of the predominant habitat type. There is good data to relate habitat and population size.



Therefore HS6 will vary from 0.25 to 1.00

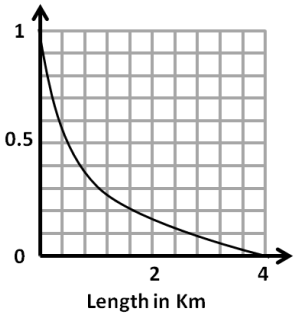
HS6 is a mechanistic based variable.

Variable 7 Barriers and Roads HS7

Roads form the greatest barrier and danger to hedgehogs. Minor roads are less of a barrier than major ones. For this variable measure the length of major and minor roads and read the HS value from the graphs.

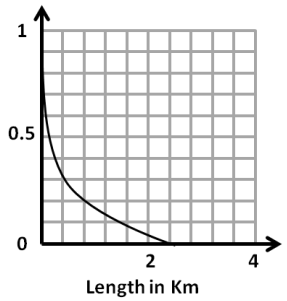
$HS7^{min}$

Minor Roads – Sub-urban Streets and Lanes up to B-Roads.



$HS7^{maj}$

Major Roads – Busy Urban Routes, A-roads, Dual Track and Motorways.



Notable Issues: Are these curves truly representative? They are currently based on an arbitrary curve generated by a general understanding on the effect of roads.

HS7 is a mechanistic based variable.

Calculating the final HSI Value

For each defined area (ideally 1 km^2) the following formula takes into account each variable to calculate a suitable index of Habitat Suitability. The closer to the value of 1 the more suitable the area is for hedgehogs.

$$\frac{HS1 + HS2 + HS3 + HS4 + HS5 + HS6 + HS7}{7} = HSI$$

3.5 Techniques for data collection

Variable	*Suggested Technique*
Geographic Distribution	Use maps provided
Primary Habitat	JNCC Phase 1 Habitat Survey
Soil Type	Geological Map and/or simple soil sample
Badger Sett Density	Badger Survey/Survey
% Cover of Habitat	JNCC Phase 1 Habitat Survey
Length of Hedgerows	JNCC Phase 1 Habitat Survey/OS Map
Number of Hibernacula sites	Site Survey
Number of Summer Nest sites	Site Survey
Population Density – Primary Habitat	JNCC Phase 1 Habitat Survey
Length of Minor Roads	OS Map
Length of Major Roads	OS Map

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Mark Smith, 2 Beaufell Close, Woodloes Park, Warwick, CV34 5UG.
admin@wildwarwickshire.co.uk www.wildwarwickshire.co.uk
www.musingsonthewild.blogspot.com