



GROWING LOCAL ENERGY

## A report on the development of the Hedgerow Biodiversity Protocol

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## Executive summary

The introduction of coppice management for woodfuel production is likely to have both positive and negative impacts on the wildlife of individual hedges and on biodiversity at a landscape scale, but how do we quantify and monitor these impacts? To address this, a protocol was developed by The Organic Research Centre that can be carried out prior to and during the implementation of any new management regime to assess the likely impacts on biodiversity of managing hedgerows for woodfuel. This document outlines how the hedgerow biodiversity protocol was developed.

The protocol is largely based on a set of indicators selected to provide quantitative links between, for example, habitat quality or structural diversity and biodiversity. Indicators were selected from a range of sources, including a review of current literature and a synthesis of existing knowledge. Methodologies to measure each of the selected indicators were developed, where possible these methods are based on existing tried and tested methods for example the DEFRA hedge survey methods and the British Trust for Ornithology's breeding bird survey. Methods for measuring each indicator were tested in the field during the protocol development phase.

The final protocol consists of three main components: an Excel assessment tool, a user guide, and a series of surveys (with accompanying survey notes) carried out each individual hedge and the associated flora and fauna. The output is a report which scores each of the indicators giving an overall picture of the biodiversity value of a hedge network and the relative value of individual hedges within the network. The protocol also identifies hedges suitable for harvesting woodfuel and those of potentially high biodiversity value as well as those in need of improvement and offers general management recommendations based on different indicators.

## Introduction

Hedgerows and their related features provide a wide range of ecosystem services. Biodiversity in British hedgerows has been well studied with hedgerows having been found to offer multiple micro-habitats, food sources, habitat refuges, and ecological corridors for a diverse range of flora and fauna. Given their significance in supporting biodiversity and ecosystem services, if hedgerows are to be widely promoted as a source of woodfuel, any potential biodiversity impacts need to be assessed.

The potential impacts of introducing coppice management for woodfuel to a proportion of hedges on a farm include an alteration of the hedge microclimate, changes in hedge structure, plant species composition and landscape connectivity. Species such as dormice which are gap adverse may be adversely affected by coppicing; however where there may be loss of habitat for some species there will be habitat creation for others. Due to this variability in species requirement and use of hedgerows, it is unlikely that one single prescription of hedgerow management can meet the needs of all wildlife in a given area.

To assess the impacts of hedge management for woodfuel on biodiversity an idea of the current biodiversity status is needed. This gives a baseline with which to compare the impacts of changes in management. Priorities also need to be identified, for example hedges that are being used by certain key species, so that management can be targeted accordingly. Measured biodiversity also needs to be put in the context of the surrounding landscape (e.g. the intensity and type of agriculture, the range of habitat types present and the extent and type of non-crop habitats).

This protocol is designed to be used by farmers, landowners and advisors and aims to assess the value of existing hedgerow networks in terms of biodiversity and to monitor the impacts of hedge coppicing on biodiversity. The protocol is based on a series of rapid biodiversity assessments and current knowledge on the likely impacts on the various aspects of biodiversity in hedgerows. The information gained from carrying out the protocol can be used to inform management decisions, aid planning, identify hedges suitable for harvesting woodfuel and those of potentially high biodiversity value.

## Protocol design

The protocol consists of three main components: an Excel assessment tool, a user guide, and a series of surveys carried out on hedges (with accompanying survey notes), butterflies, bumblebees, birds, and ground flora. All are available to download from <http://tinyurl/TWECOM> or [www.twecom.eu](http://www.twecom.eu). The user guide outlines six steps for the user to follow to complete the protocol. Step 1 involved mapping the hedgerow network, identifying individual hedges and measuring their length. Step 2 is the hedge survey which aims to collect information on each of the hedges physical condition and is compulsory for the protocol. Step 3 involves a number of additional non-compulsory surveys which cover birds, bumblebees, butterflies and ground flora. Data collected from these surveys is then entered into the assessment tool during Step 4. Step 5 helps the user interpret the results and scores calculated by the tool for different indicators of biodiversity. In the final step, Step 6, users can then view management recommendations based on different indicators.

## *Indicator selection*

Surveying the full range of taxonomic groups found on one farm to directly quantify biodiversity is time consuming, knowledge intensive and ultimately fairly unrealistic. To overcome these difficulties the protocol is largely based on the use of indicators providing quantitative links between landscape patterns, such as habitat diversity and quality, and biodiversity (Dauber et al., 2003).

Instead of providing direct evidence of the level of biodiversity, indicators often use proxies, such as bird communities, to give an indication of the existence of a habitat type. Other practical indicators include habitat diversity, habitat quality, and management interventions. An ideal biodiversity indicator is easy to observe or identify without specialist equipment or knowledge, and likely to be present or implemented when farm management is at an acceptable level (Dudley et al., 2005).

Indicators of course have their limitations, for example habitat quality may indicate the likelihood of that certain species will be present but offer no evidence. Equally the use of management interventions is based on the assumption their use will improve wildlife habitats but again offer no evidence.

The protocol therefore uses a number of indicators identified from a review of current literature and our knowledge and understanding of biodiversity on farms. Indicators were selected based on habitat quality and diversity, and additionally a range of bioindicators were identified. Scores ranging from 1 to 5 were then applied to each indicator to aid interpretation of the results.

### *Indicators based on habitat quantity and quality*

Six indicators based on habitat quantity and quality were developed and are calculated by undertaking a rapid survey of all the hedges within a network. Survey methods based on the Defra Hedgerow Survey Handbook (2007) are described in the accompanying user guide. The six chosen indicators are outlined below along with the rationale for scoring.

#### *1. Hedges in favourable condition*

Habitat quality can be used to indicate the likelihood that certain species will be present (Dudley et al., 2005). It is however important to assess both habitat quantity and quality. Based on the criteria used by the Defra Hedgerow Survey, the protocol assesses whether a particular hedgerow is in 'favourable condition' and uses the indicator 'percentage of hedge network in favourable condition'.

The attributes deemed to be indicative of whether a hedge is in 'favourable condition' were developed and defined by the Steering Group for the UK BAP for Hedgerows and can be found in Table 1. In The attributes highlighted in green were selected for use in the biodiversity protocol and form one of the main benchmarks against which any decline or improvement in hedge condition can be monitored. Those attributes not selected for use in the protocol were excluded on the basis that they may require expert knowledge (e.g. percentage cover of non-native herbaceous species) or are sufficiently picked up by other attributes (e.g. cross-sectional area is sufficiently covered by average width and height).



**Table 1. Criteria used to assess whether a hedge is in 'favourable condition' as defined by the Steering Group for the UK BAP for Hedgerows (Defra's hedgerow survey handbook, 2007). Attributes highlighted in green are used in the hedgerow biodiversity protocol.**

Attribute	Threshold	Method
Undisturbed ground	Undisturbed ground (At least 2m)	Estimate average width of uncultivated ground. Automatically favourable is borders grassland
Perennial herbaceous vegetation cover	Herbaceous vegetation (At least 1m)	Estimate average width of perennial herbaceous vegetation between the centre-line of the hedgerow and adjacent disturbed ground.
Nutrient enrichment	No suitable thresholds have been developed, but should be less than 20% combined cover of nettles, cleavers and docks	Estimate % cover of nettles, cleavers, docks within a 2m wide band alongside the hedgerow
Non-native species (herbaceous species)	Non-native herbaceous species. (Maximum 10%)	Estimate cover of all non-native herbaceous species as percentage of area of 2m band extending from centre-line of hedgerow.
Non-native species (woody species)	Non-native woody species. (Maximum 10%)	Estimate cover of all non-native woody species as a % of area of vertical face of the hedge
Size (height)	(At least 1m)	Measure average height excluding bank
Size (width)	(At least 1.5m)	Measure average width at widest point of hedge canopy (shoot tip to shoot tip)
Cross-sectional area	Minimum 3m <sup>2</sup>	Take the 'average' height and width for the hedgerow, and multiply to give the cross-sectional area.
Integrity/continuity (gaps)	No gaps >5m	Record if any gaps > 5m wide excluding access points.
Integrity/continuity (gaps)	<10% gaps	Estimate total length of gaps present as a percentage of total length
Integrity/continuity (base canopy of shrub)	Base of canopy less than 0.5m above ground for shrubby hedgerows	Estimate average height from base of the hedgerow to the lowest leafy growth

The attributes selected by the UK BAP for hedgerows steering group are supported by research on biodiversity within hedgerows. For example, both bird species richness and abundance have been shown to increase with increasing hedge height and width (Hinsley and Bellamy 2000). Hedgerow height and width have also been to be positively correlated with invertebrate and plant diversity (Maudsley, 2000; Staley, et al., 2012).

#### *Scoring:*

In developing a scoring system for the indicator 'percentage of hedges in favourable condition', it was assumed that the more hedges in favourable condition the better your hedgerow network is for biodiversity. The scoring system shown in Table 2 was therefore chosen based on 100% of your network in favourable condition being the most desirable result and 0% the least.

**Table 2. Scores allocated to different ranges of percentages of hedges in favourable condition.**

Percentage of hedges in favourable condition	Score
0-20%	1
21-40%	2
41-60%	3
61-80%	4
81-100%	5

## **2. Density of hedgerow trees**

Hedgerow trees are of great importance to wildlife with 57% of the 130 priority BAP species associated with hedges known to use hedgerow trees at some point in their lifecycle (Wolton, 2013). The presence of scattered mature hedgerow trees on a farm is therefore likely to benefit numerous species. The average number of hedgerow trees per kilometre of hedge was therefore chosen as an indicator for the protocol.

### **Scoring:**

Under the UK Hedgerows Regulations 1997, one of the attributes of an 'important' hedgerow is that there is at least one standard tree per 50 metres. Two trees per 100m of hedge was also the specified density for agri-environmental payment options in England under Countryside Stewardship (2013). However, if a hedge has too many large hedgerow trees within it, hedgerow shrubs and coppice regrowth may be shaded out resulting in gaps.

On the basis that one hedgerow tree every 50m is thought by the UK government to be a desirable density of hedgerow trees, the scoring system in Table 3 was developed. To address the issue of out-shading when there are too many trees present in a hedge, additional scores have been added for when the average number of hedgerow trees per km exceeds the recommended density.

**Table 3. Scores allocated to different ranges of average number of hedgerow trees per km of hedge.**

Range of average number of hedgerow trees per km of hedge	Score
0-4	1
5-8	2
9-12	3
13-16	4
17-24	5
25-32	3
>33	1

## **3. Hedgerow network density**

Loss of hedgerows has been identified as a major factor in the decline of many of the plant and animal species associated with agricultural landscapes in the UK (Evans *et. al.*, 2013). Reasons for the decline in the quantity and quality of hedgerows include the loss of a direct economic value, agricultural intensification, and the abandonment of traditional management practice such as coppicing and hedgelaying. Density of hedge network is likely to be positively associated with biodiversity. The density of hedges on a farm was therefore chosen as an indicator and is calculated as the length of hedgerow (km) divided by the farm area (ha).

### *Scoring:*

It was reported in 2007, that there was around 700,000 km of hedgerow in Great Britain (Carey et al., 2007). Assuming there to be 17,200,000 hectares of agricultural land in the UK (DEFRA, 2011) subtracting the 998,000 hectares of agricultural land in Northern Ireland (DARDNI, 2013), the average hedge density in Great Britain equals around 0.04 km of hedge per hectare. This is of course a low density as the total hectares of agricultural land in Great Britain will include upland farms and other areas where hedges are a less common landscape feature. The hedge density range of 0.01 to 0.04 km per ha was therefore given a lower score of '2' (Table 4). The upper ranges were based on the average hedge density of three livestock farms in the south of England (0.14 km/ha) believed to have a high density of hedges (Table 5). Densities over 0.10 km per ha were therefore given the highest score.

**Table 4. Scores allocated to different ranges of average hedge length per hectare.**

Hedge density (km per ha)	Score
<0.01	1
0.01-0.04	2
0.05-0.08	3
0.09 – 0.10	4
>0.10	5

**Table 5. Hedge density of three livestock farms in the south of England with a high density of hedges.**










Farm	Farm size (ha)	Hedge length (km)	Hedge density
1	85	9.50	0.11
2	146	19.30	0.13
3	30	5.07	0.17
MEAN			0.14



#### 4. Structural diversity of hedges

Habitat heterogeneity is closely associated with biodiversity. It is argued by Benton et al. (2003) that the loss of habitat heterogeneity at both temporal and spatial scales is a 'universal consequence of agricultural intensification' and that restoring it is key to restoring and maintaining biodiversity within our agricultural systems. Although hedges are highly regarded for their biodiversity value, it is unlikely a hedgerow network consisting of hedges of the same growth stage can meet the needs of a wide range of flora and fauna. The number of hedge growth stages present on the farm was therefore used as an indicator to determine the structural diversity of hedges. Seven growth stage categories were chosen (Table 6) based on those used in the Defra hedgerow survey handbook (2007). Stages (a) and (b) which describe overtrimmed hedges were excluded as not representing desirable habitat management.

**Table 6. The nine hedge growth stages, stages (c) – (i) were selected for use in the protocol.**

			
a) Over trimmed, many gaps and sparse stems	b) Over trimmed, frequent healthy stems, requires height	c) Recently laid	d) Coppiced within the last 5 years
			
e) Planted within the last 5 years	f) Healthy dense hedge, frequent stems and over 2m in height	g) Over 3m and unmanaged for several years or on rotation	h) Over-mature gappy hedge
			
i) Hedge developed into a line of trees			

### Scoring:

The following scoring system (Table 7) was developed for the structural diversity of hedges indicator based on the seven growth categories identified and the principal that the more habitat diversity the better your hedge network is for biodiversity.

**Table 7. Scores allocated based on the number of hedge growth stage present on a farm.**

Number of hedge growth stages present on the farm (excl A & B)	Score
0-1	1
2	2
3	3
4	4
5-7	5

## 5. Food resources

Hedges provide food resources for a wide range of species, and are especially important in providing fruit for both birds and small mammals. Hedgerow management has a strong influence on fruit (berries and nuts) production with hedges that are cut every three years producing more than three times as many berries as those that are trimmed every year and 40% more berries than those cut every two years (Staley *et.al.*, 2012). The percentage of hedges providing a good resource in terms of berry and nut production was therefore chosen as an indicator.

Whether a hedge is classed as being a good food resource within the protocol has been calculated as a function of whether the dominant species present produce fruit (nuts or berries) and how the hedge is currently managed (Table 8). To be considered as a good food resource, a hedge must have at least one of the woody species listed as a dominant species and be managed using one of the prescriptions shown.

**Table 8. Criteria for hedges providing a good food resource.**

Species which produce nuts/berries		Hedge management favourable for food resources
Apple, crab	Bramble	C) flailed every 3 to 5 years
Beech	Cherry, wild	D) side flailed only
Blackthorn	Elder	F) laid
Buckthorn	Rose	H) no management
Hawthorn	Hazel	
Holly	Oak	
Plum, wild	Rowan	

### Scoring:

As with the favourable condition indicator, it is assumed that the more hedges providing a good food resource, the better your hedgerow network is for biodiversity. The scoring system shown in Table 9 was therefore chosen based on 100% of your network providing a good food resource being the most desirable result and 0% the least.

**Table 9. Allocated scores based on the percentage of hedges providing a good resource.**

Percentage of hedges in providing a good resource	Score
0-20%	1
21-40%	2
41-60%	3
61-80%	4
81-100%	5

## 6. Connectivity

Hedgerows, particularly those connected to woodland, have been found to provide additional habitat and act as wildlife corridors facilitating the movement and dispersal of species such as dormice and some species of butterflies (Bright and MacPherson, 2002, Lawton et al. 2010, Dover, 2000). Increasing hedgerow habitat and landscape connectivity should therefore be beneficial to these and other species especially if hedges are combined and connected to other semi-natural features such as ponds and woodlands (Hinsley and Bellamy, 2000).

In general, hedges in good condition with good continuity (few or no gaps) will be providing good connectivity. The percentage of hedges classed as having good continuity was therefore selected as an indicator. To be classed as having good continuity a hedge must meet the criteria shown in Table 10.

**Table 10. Criteria for a hedge with good continuity.**

Criteria for 'good continuity'
<ul style="list-style-type: none"> <li>• Less than 10% gaps</li> <li>• No gaps over 5m</li> <li>• A base canopy under 0.5m</li> <li>• At a growth stage good for connectivity: <ul style="list-style-type: none"> <li>B) Over trimmed but frequent healthy stems</li> <li>C) Recently laid</li> <li>F) Healthy dense hedge, frequent stems and over 2m in height</li> <li>G) Over 3m and unmanaged for several years or on rotation</li> </ul> </li> </ul>

### Scoring:

Once again, the scoring system is based on the principal of the more hedges with good continuity the better your hedgerow network is for biodiversity. The scoring system shown in Table 11 was therefore chosen based on 100% of your hedges having good continuity being most desirable and 0% the least.

**Table 11. Allocated scores based on the percentage of hedges considered to have good continuity**

Percentage of hedges with good continuity	Score
0-20%	1
21-40%	2
41-60%	3
61-80%	4
81-100%	5

## **Bioindicators**

Use of bioindicators can provide rapid collection of data that may otherwise be too costly, in terms of both labour and money, to collect. Four classes of bioindicators were chosen for inclusion in this protocol: birds, bumblebees, butterflies and ground flora. Through monitoring these groups using the protocol, users can see how the abundance, species richness and diversity of these taxa are affected by changes in hedgerow management.

Simple survey methods have been designed to collect data on the number of individuals and the number of species within each taxonomic group. This data is then used to calculate a Simpson's Index of Diversity for each individual hedge, each taxa surveyed and for the farm as a whole. These surveys are additional to the main hedge survey providing an extra level of detail but are not essential for the completion of the protocol. These surveys can be carried out on all hedges present on a farm or on a subset of hedges such as those suspected to be of particular importance to wildlife, those earmarked for management, or simply a random selection for ongoing monitoring. Further detail of all survey methods can be found in the protocol user guide available to download from <http://tinyurl/TWECOM> or [www.twecom.eu](http://www.twecom.eu).

## **Birds**

Birds are often used as bioindicators because their ecology and habitat preferences are well understood, they are sensitive to environmental change, easy to detect and present in a wide range of environments (Padoa-Schioppa et al., 2006; Quinn et al., 2012). Hedgerows are one of the most important surviving semi-natural habitats for birds in agricultural landscapes. They provide nesting, foraging and roosting sites, and facilitate movement across the landscape (Hinsley and Bellamy 2000). The bird survey method used in the protocol was adapted from the British Trust for Ornithology (BTO) survey ([www.bto.org](http://www.bto.org)).

## **Butterflies**

Hedgerows are an important nectar source for a number of butterfly species. Butterflies also react very quickly to change in their environment which makes them good biodiversity indicators. Pressures such as agricultural intensification and loss of habitat have resulted in many common butterfly species having undergone serious declines. The butterfly survey methods used in the protocol were modelled on Butterfly Conservation's Wider Countryside Butterfly Survey (<http://butterfly-conservation.org/113/Wider-CountrysideButterflySurvey.html>).

## **Bumblebees**

Although bumblebees contribute over £400 million a year to the British economy through pollinating crops, they are facing large declines across the country. Hedgerows are particularly important in providing forage plants for bumblebees at the start and end of the nesting season, when flower-rich

grassland areas are yet to flower or being grazed or cut. The bumblebee survey methods were based on the Bumblebee Conservation Trust's BeeWalk ([www.bumblebeeconservation.org](http://www.bumblebeeconservation.org)).

### *Floristic Diversity*

A hedge containing a wide range of woody species is likely to provide habitat diversity, and a range of food resources throughout the year (Hinsley and Bellamy, 2000). The associated ground flora is also an important component of a hedgerow. It can contribute significantly to overall species diversity providing amongst other benefits an important food resource to a wide range of wildlife such as butterflies and bees (Maudsley, 2000). The ground flora survey method is adapted from the Defra Hedgerow Survey Handbook (2007). However only presence of a species is recorded rather than percentage cover as this can be challenging and often subjective.

### *Hedgelink Flagship Species*

Hedgelink, a partnership that has responsibility for helping to deliver the Habitat Action Plan part of the UK's Hedgerow Biodiversity Action Plan, have identified 12 flagships species against to which to measure the impact of its policies, action and advice. Collectively these species use each of the main structural components of hedgerows (tree, shrub, bank, base, and margin), and include representatives of each of the main taxonomic groups.

1. Purple rampion fumitory (*Fumaria purpurea*)
2. Orange-fruited elm-lichen (*Caloplaca luteoalba*)
3. Large (Moss) Carder bee (*Bombus muscorum*)
4. Brown hairstreak butterfly (*Thecla betulae*)
5. Goat moth (*Cossus cossus*)
6. Common lizard (*Zootoca vivipara*)
7. Bullfinch (*Pyrrhula pyrrhula*)
8. Tree sparrow *Passer (montanus)*
9. Yellowhammer (*Emberiza citronella*)
10. Soprano pipistrelle (*Pipistrellus pygmaeus*)
11. Hedgehog (*Erinaceus europaeus*)
12. Dormouse (*Muscardinus avellanarius*)

Although no additional survey was developed to collect data on these species, users of the protocol are asked whether or not they are aware of any of these 12 species being present on their farm.

## Survey development

In order to collect the required data to calculate the selected indicators and scores a series of surveys were developed:

- A hedge survey which focuses on collecting data on the health and physical character of the hedge – **the habitat quality and quantity indicators**.
- Four additional surveys that provide a more direct measure of biodiversity value through recording birds, butterflies, bees, and ground flora – **the bioindicators**.

Detailed methods, survey sheets and a tool to calculate and display your results can be found in the accompanying User Guide, Survey Notes and Assessment Tool which can be downloaded from <http://tinyurl/TWECOM> or [www.twecom.eu](http://www.twecom.eu).



## Assessment tool

The assessment tool has been developed as an Excel-based tool where data collected from the surveys can be entered and the results calculated for the user. The tool consists of 25 spreadsheets: introduction (1 sheet); data entry sheets (6 sheets); calculation sheets (5 sheets); scores (1 sheet); lists (1 sheet); graphs (3 sheets); results (1 sheet); recommendations (1 sheet); survey sheets (6 sheets).

Data from the surveys is entered into the data entry sheets by the user. The results of these surveys are then calculated in the calculation and graph sheets which are hidden from the user. The results are then displayed in the results sheet for the user to view. The tool also contains a sheet containing management recommendations and all of the required survey sheets to carry out the protocol surveys. The tool can be used to view and compare the results from previous years and monitor any changes. Further detail on how to use the tool can be found in the protocol user guide available at <http://tinyurl/TWECOM> or [www.twecom.eu](http://www.twecom.eu).

## Hedge management for wood fuel

A further output from the tool is the identification of hedges which are potentially suitable for coppice management. This is based on the woody species present and the growth stage being suitable for coppice management, the criteria are outlined in Table 12. It should be noted that this is a snap shot and only identifies hedges suitable for coppice management at the point in time of the survey.

**Table 12. Criteria used to determine whether a hedge is suitable for coppicing.**

Criteria for a hedge potentially suitable for coppicing		
Have at least one of the below suitable species for coppicing as a dominant species:		Be at one of the following growth stages:
Alder, common	Sycamore	G) Over 3m and unmanaged for several years or on rotation
Hazel	Willow, goat	
Hawthorn	Willow, grey	
Oak, pedunculate	Poplar, black	H) Over-mature gappy hedge
Oak, sessile	Maple, field	
Rowan	Birch, silver	
Sweet chestnut	Birch, downy	I) Hedge developed into a line of trees
Lime, large-leaved	Beech	
Lime, small-leaved		

## Piloting

Two on-farm pilots of the protocol and assessment tool were carried out in July 2015; one undertaken by researchers and the other by supervised volunteers. Further feedback was received from researchers involved in the development of other Excel-based assessment tools.

### *On-farm pilots*

The first pilot of the biodiversity protocol involved trialling the survey methods and data collection sheets on three hedges at Elm Farm of different character: a newly planted hedge, a recently laid hedge and a tall over grown hedge. The second pilot was carried out by three volunteers with little knowledge on species identification or experience in surveying hedges. Volunteers were supervised by a researcher involved in the development of the protocol. The pilot took place on Elm Farm and six hedges of distinct character were surveyed. Due to poor weather conditions the bird, butterfly and bumblebee surveys were not carried out although feedback on the survey sheets was received.



**Figure 1. Volunteers piloting the biodiversity protocol at Elm Farm. Left: estimating the average height of a hedge using a 2m length of pipe. Right: setting up a ground flora quadrat to undertake the ground flora survey**

General feedback included:

- Farmers may find the additional surveys too time consuming and be discouraged from undertaking the protocol. The bird, bee and butterfly surveys also require good weather; farmers are likely to be busy during these times.
- Too many survey sheets
- Estimating the percentage cover of woody species and ground flora species is time consuming and subjective
- It is difficult to identify and count the number of individuals in both the butterfly and bumblebee surveys.

Recommendations:

- Additional surveys could be undertaken on a sub-set of hedges chosen by the farmer.

- Reduce the number of survey sheets and integrate ID guides into survey sheets where possible
- Replace estimation of percentage cover by listing the three most dominant woody species for the hedge survey and simple recording the presence of different species in the ground flora survey.
- Develop abundance-only surveys where only the number of individuals is recorded not species

## Conclusion

The Hedgerow Biodiversity Protocol gives farmers, landowners and advisers a method to quantify the current condition and value of a hedgerow network to biodiversity, to monitor the potential impacts of altering management and to aid management decisions for both biodiversity and woodfuel production. The protocol has however had relatively little testing and represents just one approach to quantifying hedgerow biodiversity. There are many other assessment methods and potential indicators which have not been included. Through future use, the protocol can be further developed and improvements made to the indicators and how they are calculated and scored. Currently, some users may receive low scores through no fault of their own due to tool development having been based on hedgerow networks in the south of the UK. The protocol does not currently reflect regional variation in hedge characteristics. There is therefore potential for future adaptations for different regions and even EU countries. For example, specific species lists and hedge characteristics for different regions could be developed and made available. Although the protocol can be repeated over time to monitor the effects of management changes, it is important for users to remember that effects on certain indicators may take several years to become apparent, especially the bioindicators which involve mobile species such as birds.

To make the protocol easy to use there is scope for the development of an app that can be used on a smart phone or tablet that facilitates data collection in the field and feeds directly into the assessment tool eliminating the need for time consuming data entry. Species identification apps could also be further investigated as a resource for identifying species when out in the field.

As with most early developments of assessment tools, future improvements to the hedgerow biodiversity protocol depend on its continued adoption and use by users. Please contact [jo.s@organicresearchcentre.com](mailto:jo.s@organicresearchcentre.com) or [elmfarm@organicresearchcentre.com](mailto:elmfarm@organicresearchcentre.com) if you are interested in being involved in this development.

<http://tinyurl/TWECOM>

[www.twecom.com](http://www.twecom.com)

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