Appendix 5

Optimum Shelter Belts

How to Guide

Monitoring the crop impacts of your Optimum Shelter Belt

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Introduction

Shelterbelts are rows of trees or shrubs that reduce the force of the wind. They can reduce soil erosion, increase crop yields and protect livestock from heat and cold. They beautify the landscape and also support biodiversity. They offer sources of feed, nesting and shelter for insects, birds and mammals, and provide habitats and corridors for wildlife that are becoming the theme of many national biodiversity strategies. This how to guide supports the standardised monitoring of the crop impacts of establishing OSBs at 22 sites. It is hoped that the results, quantifying any changes attributable to the presence of the OSB, will be of great interest to landowners and many categories of professionals.

General approach

Shelterbelts within agricultural fields may have impacts on the growth and productivity of the associated crops. Associated crops may be permanent pastures or ley phases of arable rotations, or arable or horticultural crops. Impacts on these crops may be positive, due to impacts on microclimate e.g. reductions in wind speeds, warmer temperatures, or negative, due to shading and competition. The direction and magnitude of these effects may vary depending on the distance from the shelterbelt and location relative to prevailing winds. The sampling protocols described here are designed to ensure that these sources of variation are accounted for when determining impacts of OSBs on crops.

A summary of the protocols proposed for each type of crop is shown in

Table 1. Details of the protocols to follow for each of these assessments are provided in Protocols.

Table 1 Summary of proposed protocols for monitoring shelterbelt impacts in a range of crop types

	Large field arable crop (e.g. cereals, oilseed rape, potatoes)	Annual vegetables	Fruit trees and shrubs	Grass/legume (permanent pasture or temporary ley)
Crop growth	Visual or NDVI[20]	Visual or NDVI	NA	Sward stick/rising plate metre or NDVI
Frost damage	Visual estimate following frost event	Visual estimate following frost event	Visual estimate following frost event	NA
Wind damage	Visual assessment of lodging pre-harvest	Visual assessment of lodging pre-harvest	Visual assessment of lodging pre-harvest	NA
Disease assessment	Visual estimate at GS61 for cereals; when blight risk is high for potatoes; critical growth stage for other crops	Visual assessment at critical growth stage (TBD for specific crop)	Visual assessment at critical growth stage (TBD for specific crop)	NA
Insect damage	Aphids in cereals when pressure is high; flea beetles in OSR; aphids in potatoes	Visual assessment based on in-field assessment of pest pressure	Visual assessment based on in-field assessment of pest pressure	NA
Crop yield	Grab sample or yield monitoring combine	Grab sample/point assessment by farmer	Grab sample/point assessment by farmer	Sum of RPM measurements

Sampling design

Assessments of crop health and development may be conducted at the same time and using the same locations as other assessments such as carbon and biodiversity. The sample locations for these assessments have been selected taking into account directions of prevailing winds as shown in Figure 3. Three locations are identified for crop assessments at progressively further from the tree row.

[20] Normalised difference vegetation index

Sampling Point Data:

fid	x	y
17	413398.8520388725	220311.2915191147
39	413405.9956246863	220304.2937207666
61	413420.2827963138	220290.2981240702
82	413391.7084530588	220318.2893174629
122	413426.6922216847	220354.0019146019
123	413356.7246844328	220282.5767203239

Shelterbelt #1: Aston Farm

Legend

● Sampling Points ~ Shelterbelts

Farming & Wildlife Advisory Group FWAG SouthWest

Shelterbelt Information:

ID	Farm Name	Both sides owned?	Soil Type	Soil Description
1	Aston Farm	yes	SHERBORNE	shallow clay over limestone

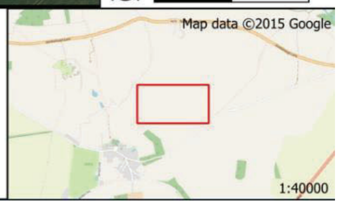

Figure 3 Proposed sampling design for impacts of OSBs on crop growth and development

Protocols

Crop Growth

Rationale

There is an expectation that trees within a field can have multiple positive and negative impacts on crop growth and development. Some measure of crop growth is therefore important to better understand these effects.

Tier 1 Visual estimates – arable crops and annual vegetables

A simple estimate of crop cover is to visually estimate the percentage of crop cover relative to bare ground. This method is very inaccurate and subjective and should only be used as a last resort.

Typically, images liked the ones shown in Annex 1 are used to provide guidelines for these estimates. These estimates should be taken early in the season when it is most likely that differences between sample locations will be identified. For cereals, this would be at GS31 (beginning of stem extension), for other crops (oilseed rape, beans) assessments could be made in early spring e.g. late April/early May.

As an alternative to visually estimating percentage crop cover the app “Canopeo” (https://www.canopeoapp.com/#/login) can be installed on a phone with the iOS (Apple) system and used to estimate cover using algorithms linked to photo image analysis.

Tier2 NDVI – arable crops, annual vegetables

For cereals and annual horticultural crops, NDVI is the most appropriate method for estimating crop growth.

Normalised difference vegetation index (NDVI) has been used to estimate plant biomass since its introduction in the 1970s. It is a relatively simple index obtained by measuring the reflectance of light from growing plants in the Red (visible) and NIR (near-infrared) regions. The index is calculated as:

NDVI = (NIR – Red)/(NIR + Red) and has a value between -1 and +1

Reflectance can be measured using satellite images, UAV mounted cameras, tractor mounted or handheld devices. For the purposes of this study, a hand-held sensor[21] is recommended, unless you have access to a tractor mounted GreenSeeker™ or a UAV-mounted device which can measure visible and NIR regions.

Timing Measurement should be taken at a stage when biomass is highly correlated with yield. For cereal crops, this is milk grain stage (GS71-77[22]) (Marti et al. 2007). For vegetables, the most appropriate time will depend on the type, but ideally measurements should be taken at maximum leaf development i.e. pre-senescence, to assess relative size of the crop canopy.

Method To get a reasonable estimate of NDVI several readings should be taken at each location. Stand at the sample location and take four readings, each at 90° to the previous one (Figure 4). Penn State University[23] provides some useful guidance on how to collect accurate measurements with the GreenSeeker. Their guidance on how to take a point measurement are as follows:

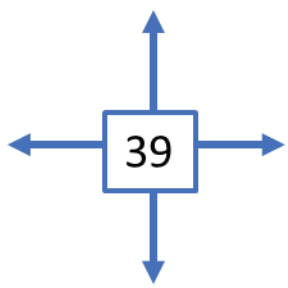

Figure 4 Schematic showing approach to assessments at each sample location; a measurement should be recorded in each of the four directions or points indicated by the perpendicular arrows.

1. Hold the Greenseeker sensor to the side of the body at arm's length, at a constant high between two and four feet above the top of the crop canopy.
2. Pull the trigger on the handle and the sensor will start flashing red and infrared LED lights onto the cover crop canopy. Depress the trigger for several seconds while holding the sensor over the sample location. The digital display on the top of the sensor will read the NDVI measurement several times a second. Once the trigger is released, the average NDVI value measured while the trigger was pulled will be displayed for a few seconds. Remember this number or write it down, as there is no way to retrieve it once the display goes blank.
3. Occasionally the sensor display will show an error code rather than the NDVI. Most often this is because the sensor is either too close, or too far away, from the canopy. If an error code occurs, adjust the sensor distance from the canopy to between two and

[21] Recent searches of the internet indicated that a handheld sensor (GreenSeeker 2) is available from Manterra for ~£572.25; a drone mounted sensor, e.g. from DroneAg, costs about £3,250. Alternatively, a company could be contracted to obtain drone imagery.

[22] Cereal growth guides for all major cereals and information on how to assess cereal growth stages are provided by the Agricultural and Horticultural Development Board on their website: https://ahdb.org.uk/knowledge-library/the-growth-stages-of-cereals

[23] https://extension.psu.edu/using-an-ndvi-sensor-to-estimate-cover-crop-nitrogen-content

four feet. If this does not correct the problem, consult the user manual to determine if the error code is due to other issues.

Equipment: Hand-held sensor - GreenSeekerTM (Trimble Inc., Sunnyvale, CA,

United States)

Crop growth in permanent pastures/leys

The AHDB has produced a useful summary of various methods to assess forage biomass at this link.

Tier 1 Compressed sward stick or rising plate meter

A simple way to estimate forage biomass is through using a sward stick which has been correlated to biomass. The AHDB or forage seed companies can provide these sticks for now charge. The protocol is to rest a flat object (e.g. a clipboard) on the grass and read off the corresponding height from the calibrated sward stick.

Rising plate meters can be mechanical or electronic and work in a similar way to sward sticks, but take into account the height and density of the sward to give a potentially more accurate estimate of biomass. Some plate meters give a compressed height in cm, whereas other convert this height directly to kg DM/ha and have the option of uploading the data to a computer via a USB stick.

Tier 2 NDVI in permanent pastures/leys

As described above, NDVI can also be used to estimate forage biomass either by using a handheld sensor, tractor mounted sensor, or drone operated sensor.

Timing of Forage Biomass Assessments

Forages may be harvested several times during a season, either through mechanical harvesting for hay or silage, or through periodic grazing by livestock. It is therefore important to measure the biomass before each harvest event; these figures can later be summed over the season to give total forage dry matter yield.

Method

As described above, at each sample location four measurements should be taken, each at 90^o to the previous one.

Frost damage

Rationale

The microclimate benefits of shelterbelts may be most evident after extreme weather events including periods of frost. Some crops are very susceptible to frost, e.g. maize, potatoes, strawberry blossoms, whereas others are not at risk from frost damage. Monitoring for frost damage should be focussed on those crops that are at risk.

Tier 1 – Visual assessment of damage (leaves, fruit, flowers)

This assessment will be triggered by a recorded frost event and the assessment should take place within 48 hours of that event. The damage should be reported as both:

- Incidence - % of plants in the field that have been damaged
- Severity - % area of affected plant's leaves/flowers that is damaged

Figure 5 Images of crops damaged by frost. Top left: apple blossoms showing characteristic "burning" around the flower edges. Top right: a maize seedling experiencing severe frost. Bottom: a potato plant with frost burn on many of the leaves.

<u>Timing</u>

As stated above: this monitoring would be on an *ad hoc* basis triggered by a recent frost event.

<u>Method</u>

Frost damage should be assessed at each of the three crop assessment locations described above. At each location make four assessments by observing an area ~2x2m square, each at 90° to the previous one (see Figure 4).

Wind damage

<u>Rationale</u>

Shelterbelts should protect the crops from damage due to high winds. The sum effect of wind over the growing season can be made prior to the crop harvest.

<u>Protocols</u>

<u>Tier 1 Visual estimate of damage pre-harvest</u>

Wind damage can cause broken stems, particularly in vegetables and fruit, as well as damage to leaves and lodging in cereals.

<u>Method</u>

In cereals, lodging usually becomes evident later in the season. At some point prior to harvest an estimate should be made if there is some visible lodging in the field. Record this at each sample location; it is not necessary to record at each of the four points of the compass. Instead, record a value for the level of lodging within 5 m of that location.

For horticultural crops like potatoes, report incidence and severity of wind damage in the same way as for frost damage (Figure 6).

Figure 6 Examples of wind damage. A potato plant showing damage from wind on its leaves (left) and a cereal crop suffering from lodging (right).

Disease assessments

Rationale

Diseases may be affected by microclimate, thus shelterbelts may have an impact on disease levels and distance from the trees may moderate this effect. Disease assessment techniques in arable crops are well developed, particularly by organisations such as NIAB. General recommendations for protocols follow.

Protocols

There are a number of foliar diseases commonly monitored in cereals. The main ones for each cereal are listed in Table 2.

Table 2 Main diseases of cereals to monitor in the UK

Cereal	Main diseases
Spring and Winter wheat	*Septoria tritici* blotch, Yellow rust, Brown rust, Powdery mildew
Winter and Spring barley	Powdery mildew, Brown rust, *Ramularia* leaf spot, *Rhynchosporium* (leaf scald) and Net blotch (*Dreschslera teres*)
Oats	Crown rust, Powdery mildew
Triticale	Yellow rust, *Septoria tritici*, Powdery mildew, *Rhynchosporium* (leaf scald), Brown rust, *Fusarium*
Rye	Brown rust, Powdery mildew, Ergot

Tier 1 Disease assessment

For cereals, an assessment of the disease incidence and severity on the flag leaf, F-1[24], and F-2 leaves at each sample location (at the four points of the compass shown in Figure 4) should be conducted at GS61 (flowering stage). As described above, an estimate of the percentage of leaves affected by the disease should be made (incidence) as well as an estimate of the percentage of leaf area affected (severity).

For potatoes, late blight is the main disease of concern; this is very affected by microclimate. An assessment should be conducted when the blight risk is high (use the Blightspy https://blightspy.huttonltd.com/#/forecast website to assess local risk). Incidence and severity of blight affecting the whole plant at each sample location and point should be recorded.

Figure 7 Potato leaf exhibiting late blight symptoms

For other crops (annual vegetables or perennial fruit trees and shrubs) impacts of any major diseases should be assessed at a critical growth stage.

Insect damage

Rationale

Insects pests may be positively or negatively affected by the presence of shelterbelts, so it is important to monitor their levels. Aphids are particularly a concern for cereals, potatoes and brassicas.

Protocols

Tier 1 - Visual estimates

Cereal aphids are only a problem in some years. Use the AHDB Aphid Monitoring Network to monitor local pressure and assess when pressure is high. This can be done by counting numbers of aphids on ears at flowering.

Peach-potato aphids are pest of brassicas (oilseed rape) and potato aphids are pests of potatoes that transmit viruses. Use AHDB forecasts to determine timing of assessments; and monitor

[24] One leaf below the flag leaf; F-2 is the second leaf below the flag leaf.

when pressure is high. This can be done by mounting a sticky trap[25] on a stake in the field at each of the monitoring locations. Leave the trap for 24 hours, then return and count the number of aphids caught on the trap.

Cabbage Stem Flea Beetle (CSFB) causes serious damage to OSR seedlings soon after they emerge. Monitor damage (Figure 8) at OSR emergence by recording incidence and severity of damage to the seedlings at each of the four points of the compass at each monitoring location.

Figure 8 Oilseed rape seedling showing characteristic shot-holing from cabbage stem flea beetle feeding.

Final Yield

Rationale

The most important indicator of impacts of the shelterbelts on crops will be the final yield of the crop.

Protocols

Tier 1 Hand harvesting

Yields of cereals at each sample location and point can be estimated by taking a "grab sample". This is normally done by harvesting 1 m of row, cutting at the base of the plant stem. The whole plants should be dried and total biomass recorded. Ideally, the ears should then be cut off and threshed to separate the grain from the chaff. Total grain weight for each location should be weighed.

Total biomass in t/ha and total grain yield in t/ha can be obtained if the row width is known. Typical row widths are 12.5 cm, but make sure to check this before doing the calculation. Below is an example of the calculation for a 1 m row of wheat planted in 12.5 row widths.

1. First, determine the number of 1 m lengths of row in a square meter (100 cm x 100 cm).
   # rows = 100/12.5 = 8

[25] Eco Sticky Insect Traps shown here: https://dragonfli.co.uk/products/large-yellow-eco-sticky-traps?variant=42098660507906&currency=GBP&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&src=GAds&gad_source=1&gclid=Cj0KCQjwir2xBhC_ARIsAMTXk86pBQsi2QVePwNR8NDqtj0ZS_3CtU4gJcPcICfN0ho_sXHe0wAfwfIaAgceEALw_wcB could be suitable

2. Now multiply the yield for the 1 m length of row by 8.
3. This gives you g/m^2. There are 1 million grams in a tonne and 10,000 m^2 in a hectare, so you need to take the weight in g for 1 m^2 and divide by 100 to get t/ha of grain.
4. The same calculation can be used for the total biomass of the wheat.

Oilseed rape could be harvested by hand in the same way as described for the cereals.

For potatoes, dig a 1 m row in foru locations and record the fresh weight of tubers. Calculation to convert to t fresh weight/ha would be the same as above, using the row width for potatoes.

Adapt these methods for other crops if harvesting by hand.

<u>Tier 2 Yield mapping equipment</u>

If yield mapping combines are available, then use the yield maps provided by these to determine the yields at the sample points.

Likewise, if the farm has automated equipment for precision determination of yields, then use this equipment.

Annex 1 Chart for estimating % cover of crops or % disease on leaves

From: Government of Nova Scotia. 2010. Forest Ecosystem Classification for Nova Scotia, Part 1: Vegetation Types