Landscape-scale species monitoring of agri-environment schemes (LandSpAES project)

Appendix for final project report, 2022

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Moth light trap at dawn
© Judy Hart, UKCEH

Acoustic bat detector
© Jo Staley, UKCEH

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A1 Field survey protocols

A1.1 Locating butterfly and bumblebee transects, pan traps and moth traps in 1km survey squares

- Follow this protocol only once for each survey square new to the project.
- In all years, follow the transect route and trap locations determined in 2017 or 18 (see maps and grid references for transect routes and trap locations). Only refer to this protocol if you need to relocate a trap, e.g. due to livestock.

Transect, pan and moth trap survey summary

Within each 1km survey square pollinating insects and moths will be surveyed using sampling methods as outlined in Table A1.1.

Table A1.1 Summary of butterfly, pollinator and moth sampling. Transects and pan trap surveys are carried out together in a one day protocol per square.

	Transect length / number of traps per 1km^2 survey square in one sample round	**Sampling rounds**
1. Transects for butterflies and bumblebees	2km, split into approx. 10 transect sections	4: May - August
2. Pan traps for pollinators	6	4: May - August
3. Moth light traps	6	2: June & July / August

Transects consist of ~10 sections adding up to as near to 2km within each survey square as possible.

Six of the ~10 transect sections will have an associated trap location, where pan and moth traps are set in the same place (not at the same time).

Transect and trap locations will be determined once for each new survey square, and then located in the same position for future surveys. Take some time to ensure transects and traps are located according to these guidelines.

- Once you have provisional transect routes and trap locations marked on a map, take a photo and send it to CEH project team (AESspeciesmonitoring@ceh.ac.uk) to confirm route prior to surveying

Planning guidance in order of priority; access considerations always come first.

1. Access authorization

Check your access map to determine extent of access that has been negotiated by CEH in advance for each survey square. Also consider land / field entry points (parking, gates, stiles) on your first visit to the square.

Transects should be mainly on land where permission for survey has been granted by the landowner. Do not place transect sections on rights of way where access has been denied by the landowner. If needbe a single section can be placed on a right of way where permission has not been sought, but avoid this if possible.

Where fields with access permission cross into adjacent 1km squares you can place part of a section out of the 1km square (<50% of the section length and < 10% (200m) of the overall transect length) but this should be avoided where possible.

Pan trap and moth light traps must be placed on land where CEH has negotiated access.

2. Cover as much of the 1km square as possible within accessible land

1km squares are assigned based on their overall AES content, so a good coverage of the entire square is optimal. This will be affected by access issues, but avoid confining transects or trap locations to only one part of the square e.g. all in the northern half.

Across the accessible land, position each trap location a minimum of 200m away from the other five trap locations.

3. Use linear features

Follow linear features that are likely to be permanent for the foreseeable future. This does include footpaths that cross fields where these footpaths are permanent or semi-permanent. Ephemeral footpaths and tracks should be avoided. Avoid the inside of woodland for transect sections and traps, but you can use a field boundary which borders a woodland.

On some upland squares it may not be possible to follow linear features for all transect sections. For sections that cannot be placed along a linear feature, where possible start and end the section with a landmark (e.g. large clump of rocks) and follow a straight route.

4. Transects: split into sections determined by habitat type, retain a contiguous transect where possible

Plan approximately 10 transect sections within each survey square, and cover as close to 2km of total transect length as possible.

Transect sections are defined within a single habitat type, and/or natural physical breaks if there are long stretches of certain habitat types. If the habitat changes (e.g. arable field boundary changing to grass field), start a new transect section. Due to this transect section lengths vary: use a minimum length of 50m and a maximum of 300m. If there are longer sections of a single habitat (especially in uplands), split this into two or more transect sections.

In some squares a disjointed transect may be unavoidable, but it should be avoided where possible, so aim to keep at least some sections contiguous.

- Where there are gaps between sections of the 2km transect, mark on maps the area walked between sections (with a dotted line).

5. Traps: avoid public rights of way, tracks and areas with livestock

Trap locations should be positioned a minimum distance of 200m away from other trap locations, one each on six of the ~10 transect sections. Avoid putting traps at the end of transect sections, as the aim is to sample the habitat associated with the transect section.

Traps should be set on boundary habitats, and where possible away from rights of way. Avoid putting pan trap stations in fields with livestock, or on any tracks (temporary or permanent) where farm machinery may drive.

On a grass field or wide margin, place the pan trap approximately 2m out from the boundary (hedge, ditch or fence), in a narrower (cross-compliance) margin place it in the middle of the margin width.

6. Plan sections and traps to cover on and off option land depending on 1km square category

Each survey square will fall into one of three categories for agri-environment scheme (AES) intervention at the 1km scale: low, medium or high. The area under AES option varies between squares within each gradient category – no two squares are the same.

Low squares - mostly contain no AES options, or no AES options that are relevant for the taxa monitored on this project.
Medium squares - contain some farmland under AES options, usually also include land not under option.
High squares – have either more AES options or a greater area of land under AES options than medium squares. Some high squares (especially in unenclosed upland areas) have no land without AES options.

Having prioritized all the considerations above, where possible on survey squares with AES options present, locate transect sections and traps to provide some contrast between habitats under AES option vs. off option habitats. Rough guidelines are given below Table A1.2, but it may not be possible to follow these on all squares.

Table A1.2 Rough guidelines for placing ~10 transect sections and six traps (pan and moth light traps) in relation to AES options.

	Transect length (in sections)		**Number of traps (6 in total)**	
	On/adjacent to AES option	**Off AES option**	**On/adjacent to AES option**	**Off AES option**
Low squares: few or zero AES options present	0 – 300m	1700 – 2000m	0 or 1	5 or 6
Medium squares	600 – 1700m	300 – 1400m	2 to 5	1 to 4
High squares	900 – 2000m	0 – 1200m	3 to 6	0 to 3

7. Within the 'on option' sections / locations, include some options targeted at invertebrate taxa

Try if possible to cover varied options in the 'on option transect sections and trap locations, including those for invertebrates (Table A1.3). This should not come at the expense of the previous criteria. We do not expect you to cover the full range of options, or all instances of an option in a survey square.

Ground-truth the whole square to check if there are suitable areas under these options before making these decisions. Where ground truthing reveals a square has less or more option than maps show, alter the on/off proportions accordingly.

8. Confirm proposed route and trap locations with CEH project team

Send a sketch map of proposed transect route and trap locations, with info such as on/off option, to AESspeciesmonitoring@ceh.ac.uk for confirmation prior to first survey.

Also submit: (1) descriptions of the start and end of each transect section in a spreadsheet on USB (example below)

(2) GPS coordinates of transect section start and end points (on transect data sheet)

(1) Write the transect descriptions either when you plan the transect route, or during any spare time on a subsequent transect survey.

(2) Record the GPS coordinates for transect sections on your first transect survey (and subsequent visits if these are made by a different surveyor), and for moth and pan trap locations each survey round.

9. Relocating traps away from the primary location only if needbe (e.g. if livestock present)

If it is not possible to relocate a pan or moth trap in the primary location from 2017 & 2018, then use one of the alternative locations listed for your square.

If this also is not possible (e.g. no alternative locations listed for some squares), relocate the trap to another transect section using the guidance above. If the original position was off AES option, try to move the trap to another off option transect section; if it was ‘on option’ move it to an equivalent option if possible.

If you do not use the primary location for any trap, ensure you take an accurate GPS reading and record this on the trap paper data form and the access recording database.

Table A1.3. Options which target or benefit invertebrates, for 7. above

High priority options to include*	**Environmental Stewardship (ES) codes**	**Countryside Stewardship (CS) codes**
Nectar flower mix	EF4, HF4, OHF4	AB1
Flower-rich margins and plots	HE10, EE12 (wildflower mix supplement for grass margins)	AB8
Winter bird seed mix	EF2, HF2, HF12	AB9, OP2
Bumblebird mix		AB16
Species-rich grassland	HK6, HK7, HK8	GS6, GS7, GS8
Legume fallow		AB15
Uncropped cultivated margins and areas for arable plants	EF11, HF20	AB11
Hedgerow management (or combined hedge and ditch	EB1, EB2, EB3, EB9, EB10, HB11, HB12, OB3, OEB1, OEB2, OEB9, OHE3	BE3, BN5
Organic supplement	OU1	
Scrub and successional area management	HC15, HC16	WD7
Woodland edge management	EC4	WD3
Very low input permanent grassland	EK3, OK3, EL3, OL3	GS2
Cattle grazing (upland grass and moorland)	UL18,	
Haymaking	UL20, HK18	GS15
Moorland restoration or management	HL9, HL10	
Rough grazing, grazing for birds	EL5, EL6, UL22, UL23, HL8	
Bracken control	HR5	
Management of heather, gorse and grass	HL12	

* All options in this table are high priority, not in order.

Table A1.3 continued Options which target or benefit invertebrates, for 7. above

Lower priority options to include**	ES codes	CS codes
Beetle bank	EF7, HF7	AB3
Ditch management and pond buffers	EB6, EB7, OB6	HB14, WT2
Field corners	EF1, HF1	GS1
Grass buffers and strips	EE1, EE2, EE3, EE6, EE9, HE2, HE3, OHE2, OHE3, OE2, OE3	SW1, SW3
Grassland for target species	HK15, HK16, HK17	GS13, GS14, GS15
Rush pastures	EK4, HK4, EL4, HL4	
Wet grassland	HK9, HK10, HK11, HK12	GS9, GS10, GS11, GS12
Low input grassland (don't use if possible)	EK2, HL2, EL2, OL2	

*All options in this table are lower priority, not in order.

Options not to include	ES codes	CS codes
Winter stubble	EF6, EF22	AB2
Skylark plots	HF8	AB4
Ground nesting bird plots	HF13	AB5
Supplementary bird food	HF24	AB12
Supplementary options	HR1, HR2, UL17	SP8
Woodland management and restoration	HC7, HC8	WD2

Maps and option information for planning transects and traps

Option maps

Landowner access maps

For each square there is also an access map showing where access for survey has been negotiated with landowners, which includes rights of way.

Agreement information

Example of transect section descriptions

You will be provided with transect route descriptions from 2017 & 2018 for each survey square. Save any updates on your USB and upload to Wiki when all squares in your NCA are complete. Please submit via spreadsheet.

Start_note	Mid_note	End_note	AES_info	Length	On/Off Opt
Opposite Short Elder Bush	Extent: Track ->Crop	Opposite Track Junction	SW1	194	On
Opposite corner of crop	Hedge towards crop	Opposite hedge gap	SW1	209	On
End of section 2	Hedge toward crop	Opposite footpath bridge	SW1	125	On
Opposite corner of bumblebird	margin <- track -> margin	Opposite corner of bumblebird	AB8 and AB16	211	On
Immediately north of pylon	Hedge towards crop	End of bramble 'hedge'	BN5	121	On
Opposite corner of crop	Hedge towards crop	Opposite gap in hedge	Off Option	145	Off
Opposite corner of crop	Bank towards crop	Opposite corner of crop	Off Option	256	Off
Opposite corner of crop	Margin-wide	Opposite oak tree	AB8	236	On
End of section 8	Margin-wide	Opposite gate	AB8	191	On
End of section 9	Margin-wide	Opposite oak tree	AB8	300	On

A1.2 Butterfly and bumblebee transect and pan trap protocol 2021

- This is a combined transect and pan trap protocol, designed to be carried out in one day, subject to minimum weather requirements detailed below.

- Transect and pan trap surveys will be conducted at each survey square once per month between May and August resulting in four rounds of sampling.

- Six pan trap stations will be set up in each survey square at predetermined locations (see Transect trap location protocol and 2021 trap and transect maps) prior to walking transects. Where two surveyors are present, one can start walking transects while the second sets the pan traps, within the time criteria below.

- Samples from the pan traps at each pan trap station will be collected after a **minimum of six hours**, and after the transect data has been recorded.

- Survey all squares within a particular survey round before resurveying any square, and leave a **minimum of two weeks between survey rounds** for each square.

Weather requirements and timing

Pan traps should be operating for a minimum of six hours from 9:30am onwards. Operating means set up and sampling under minimum weather conditions. Pan traps can be set up earlier than this, but if so, the operating time must start at 9:30 am (if minimum weather requirements are met: see below – if weather requirements are not met then the operating start time should be delayed until weather conditions become suitable) and last for a minimum of six hours after that. The last pan trap must be collected by 17:00 pm, therefore the latest that the last pan trap can be set up, or that the operational time can start, is 11:00 am. Bumblebee transects can be walked between 9.30 and 16.30 hours, and butterfly transects between 10:00 and 16:00 if weather conditions are suitable.

Suitable weather conditions that should be met are as follows (see below for exceptions*):

- An absolute minimum of 13˚C temperature
- Between 13-16˚C, there must be no more than 40% cloud cover
- 17˚C and above the amount of sunshine no longer matters[#]
- Do not conduct transects or set out pan traps if it is raining
- Wind speeds must not exceed 5 on the Beaufort scale

These weather criteria must be met during the recording of butterfly and bumblebee transects.

***Exceptions to weather criteria:**

In all survey squares in upland NCAs (Dartmoor and Yorkshire Dales) only, recording can take place at 11°C or above with no more than 40% cloud cover.
- Survey with >40% cloud cover if the minimum temperature is 15°C or above.
- All other criteria (wind speeds, rain) as above.

- If this reduced upland criteria is used, target the insect transect recording during the warmest time of day. For example, pan traps may be placed out at 15°C with >40% cloud at 10 or 11am, but if it is forecast to warm up, record the butterfly and bumblebee transects later in the 6 hour window.

Only use this reduced upland weather criteria if necessary; if there are other days within a survey round which meet the more stringent weather requirements for all NCAs, do not use this reduced criteria. Especially avoid using this reduced criteria in summer survey rounds (2 and 3) if possible, when it is generally likely to be warmer on average. They are most likely to be needed in rounds 1 and 4.

[#] **High temperatures**: there is anecdotal evidence to suggest that when temperatures are excessively high, insect activity decreases and so we recommend that if the temperature is forecast to exceed 27°C (or temperature readings when on site exceed 27°C) transects are completed either side of the hottest part of the day. This may be achieved, for example, by walking the bumblebee transect as early as is possible (09:30) and walking the butterfly transect later in the day, avoiding midday when temperatures are usually highest. We appreciate this adds another level of criteria to restrict when transects can be completed but do not expect these temperatures to be prevalent, and when they are the rest of the day is likely to be suitable for transect surveys anyway.

Weather criteria for pan traps

If there is a short shower during the minimum six hours that pan traps are set, this is acceptable but if possible leave the pan traps out for extra time to compensate for the time it was raining (do not record butterflies and bumblebees on transects while it is raining). Weather conditions for pan traps can differ slightly to those for insect transects (above), provided that the insect transects are recorded in periods within the 6 hours that meet the transect weather conditions.

For pan traps only:

- Between 13-16°C, pan traps can be set if there is less than 50% cloud cover.

In addition, in the uplands and for early season (May) visits to any square, pan trap minimum weather criteria can be relaxed if needbe:

- Minimum temperature of 11°C can be used under clear sky conditions and 13°C if cloud cover >50%
- From June onwards, these lower temperatures cannot be used in lowland squares for pan trapping.

The weather conditions above should be met at the start of the pan trap operating period and for at least 50% of the total 6-hour exposure.

1a) Recording the weather

Sunshine should be estimated for each transect section to the nearest 10% of the time that it was sunny while you were walking that section. If a distinct shadow is cast (bright cloud) then conditions may be classed as sunny. If there is no cloud, but you are walking in deep shade (e.g. along a line of trees), class that as not sunny. At the start of each transect, record the temperature in the shade (e.g. with a portable thermometer placed in a shaded situation at the beginning of the transect before you start), wind direction, and average wind speed, using the Beaufort scale (see below).

Beaufort scale guide:			km/h	m/h
0	Calm	Smoke rises vertically;	<1	<1
1	Light air	Slight smoke drift;	1-5	1-3
2	Light breeze	Wind felt on face;	6-11	4-7
3	Gentle breeze	Leaves in slight motion;	12-19	8-12
4	Moderate breeze	Dust raised & small branches move	20-28	13-18
5	Fresh breeze	Small trees in leaf sway;	29-38	19-24
6	Strong breeze	Large branches move & trees sway	39-49	25-31

The paper data form allows wind speed to be recorded per section as some surveyors previously struggled to define an average wind speed across the whole transect. The Access recording database only has average wind speed for each transect. If you find it easier to record wind speed per section, note these on the paper data sheet, then take the median (most frequent) Beaufort across the transect sections and enter this for the average wind speed.

1b) Recording GPS coordinates, transect routes and pan trap locations

For pan traps, relocate each trap at the primary location using the GPS coordinates given on the *2021_TrapLocationMap* for that square. If you cannot use the primary location (e.g. due to livestock), use one of the alternative locations from previous survey years, also listed on the trap location map. Only if no alternative location is suitable or listed on the map, as a last resort locate elsewhere using the *Locating transect and pan trap protocol* from previous years.

If the primary location is used for a pan trap you do not need to record the GPS coordinates – we will assume all blank coordinates relate to the primary location. If either a mapped alternative location or a new location is used, ensure you record the GPS coordinates.

Transects should follow the fixed route from previous years, shown on the *2021_TransectMap* for that square. For transect section start and end locations, record the coordinates when you as a surveyor first walk a transect within a particular square, but not on subsequent survey rounds of you follow the fixed route. If the route changes at all, record the new section start and end coordinates and alert the UKCEH project team.

Wait until the GPS accuracy reads 3-6m before recording the coordinates. When entering GPS coordinates do not enter spaces, use capital letters. Take some care as accurate GPS coordinates are essential to link the mapping and transect section/ trap data.

Setting pan traps

Each pan trap station consists of three pans or bowls, one sprayed each of UV-reflective white, yellow and blue (Figure A1.1).

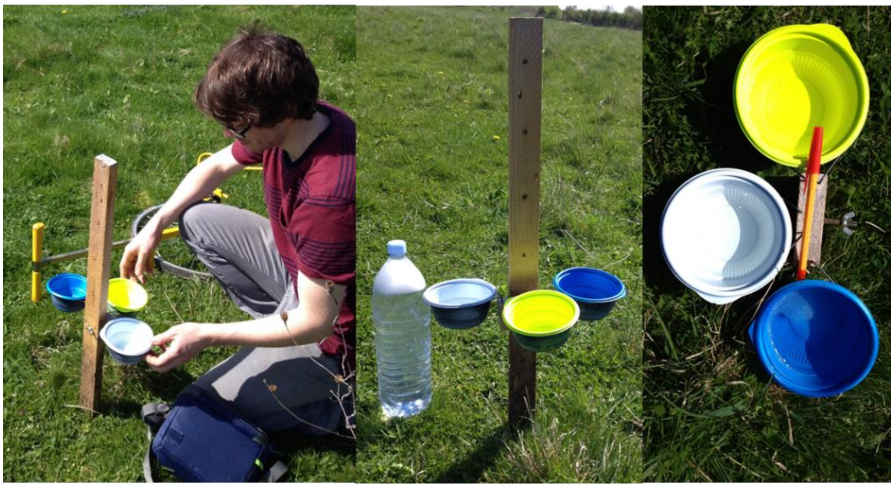


Figure A1.1 Pan trap station for sampling pollinating insects, used in National Pollinator Monitoring Scheme (Carvell et al., 2016).

a. Hammer a wooden stake into the ground using the mallet and gloves to hold the stake (to avoid splinters). If the ground is dry it may be useful to take extra water to soften it. Make sure the stakes have the UKCEH project information signs attached.
b. Attach the wire pan holder to the stake at a height even with the top of the vegetation, approximately level with the position of flowers or where flowers would be, securing it in place with the wing nut (see image below). The pan supports must be level, and the nut secure enough that they won't move. If adjacent to a hedge or other boundary, have the pan traps facing outwards.
c. **Avoid trampling the vegetation** surrounding the trap station, since estimates of flower abundance will need to be made within a 2 m radius.
d. Place three pan trap bowls: one white, one yellow and one blue into the pan holder.
e. Add a few drops of the washing up liquid provided to your large water bottle prior to setting up the pan traps, briefly and gently turn the bottle a few times to ensure mixing. Use this solution to fill each trap bowl up to the first line marked on the inside of the bowl: roughly up to the top of the ridged section (this is approx 100 ml).
f. Assess floral resources in a 2m radius circular quadrat around the pan trap station either when you set it up or collect it, as described in Section 4 below.

Butterfly and bumblebee transects

a) Where to record - transect width placement

The length of each transect section will be placed as described in the *Transect trap location protocol*, along a linear feature. Where possible, start your 5m width of transect at the boundary face (e.g. to include butterflies and bumblebees foraging on floral resources). For example, if walking a 2m wide cross compliance margin, the transect width might encompass hedge face, margin and arable crop. If walking along a path with hedge on one side and AES option on the other, the transect width might encompass hedge face, path and part of AES option. Use these rough guidelines, within the bounds of where it is feasible to walk the transect.

b) Walking the transects

Transect routes will be walked three times during each survey visit: once to record butterflies, once to record bumblebees, and finally to assess floral resources. Surveyors will be paired to cover expertise across each of these taxonomic groups and therefore two taxa can be recorded simultaneously by a surveyor pairing as long as disturbance from one surveyor does not affect the recording of the other. For example, butterfly and bumblebee surveys should always be conducted ahead of floral resources as these mobile taxa are easily disturbed. Each taxa should be recorded independently.

Transects will be walked at an even, steady pace and only the butterflies and bumblebees observed within a 5 m box around the surveyor should be recorded (up to 5 m in front, 5 m above ground and 2.5 m either side, Figure A1.2). Anything which is flying further ahead or otherwise outside of the box should not be recorded. Surveyors may wish to take note of species they have seen off transects but this is not a requirement of the protocol and should not be conducted at the expense of collecting the required data.

The focus is on species recording, so for both butterflies and bumblebees record to species wherever possible (and to caste for bumblebees) using the guidance below and the butterfly and bumblebee identification guides. It is also key to have an estimate of total abundance for these taxa, so if butterflies or bumblebees fly through your transect and a species identification isn't possible, ensure they are still recorded using the guidance below.

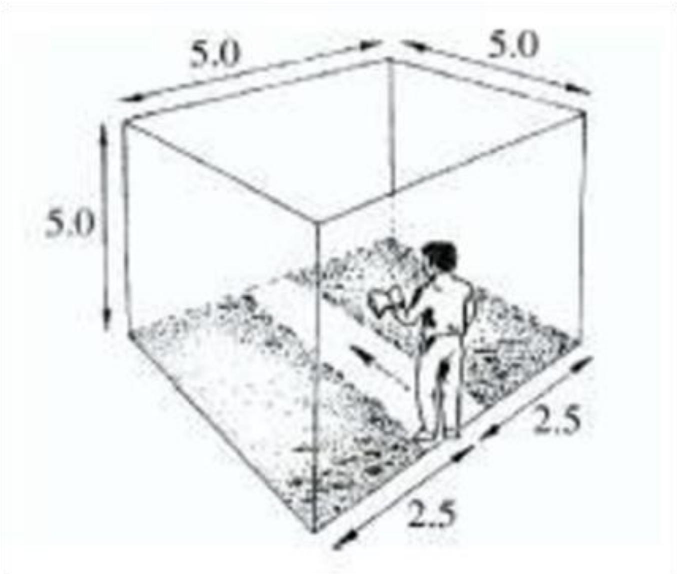


Figure A1.2 Moving box sampling approach for Pollard transects, used by WCBS and UKBMS (taken from van Swaay et al., 2012).

Recording butterflies

A net should be used to catch individuals that are difficult to identify, for example common white butterflies in the Pieridae (Large White, Small White and Green-veined White), some of the skipper butterflies (*Thymelicus* spp) and some of the Fritillaries in upland survey squares. By and large however, it is assumed that, as with the UK Butterfly Monitoring Scheme (UKBMS), the majority of butterfly species will be identifiable on the wing. When netting samples for identification, transect recording should stop. Following identification, transect recording should be resumed from the point at which it was temporarily stopped.

Recording Small/Essex Skippers

All butterflies should be recorded to species level throughout the transect route with the exception of Essex and Small Skippers (*Thymelicus lineola* and *T. sylvestris*). These two species can both be abundant in suitable habitats and are separable to species level only on seeing the underside of the antennae. As such, every individual either needs to be caught or seen extremely close-up to identify to species level and this process is time consuming. It is advised therefore, that a sub-sample of at least 20 individuals from this species pair are captured across the transect and identified to species level – it is important to try and identify individuals from different sections of the transect and not just one part of the transect and if more than 20 can be identified to species level without significantly slowing down the transect this is encouraged. This should be recorded separately and then used to calculate a ratio of Small:Essex Skippers.

Throughout the transect all skippers of this pairing should be recorded as the pairing and then at the end of the transect the number of each species on each section should be calculated using the ratio calculated from the subsample which has been accurately identified to species level. For example, if 100 Small/Essex Skippers were seen and the ratio from a sub-sample was 3 Small: 1 Essex then the total number of skippers of each species would be 75 Small and 25 Essex Skippers. This should be applied at transect section level and the whole process repeated on each separate transect visit.

When entering the data for these species into the database, please only enter records for the two individual species, Small and Essex Skippers, as calculated from the aggregate total for each section using the above methodology. Only enter records for the aggregate where you have not been able to catch and identify any individuals at all from the transect and have therefore been unable to calculate the ratio.

Recording other butterfly aggregates

Record all other butterfly records to species wherever possible. Occasionally, other aggregated butterfly species records may need to be used, for example for Pearl-bordered Fritillary and Small Pearl-bordered Fritillary. Five aggregated categories are included on the butterfly recording form drop down in the database: Small/Essex Skipper, Pearl-bordered/Spb Fritillary, Dark green/High brown Fritillary, Small/Green-veined White and Other butterfly. If you use the Other butterfly category include a note to explain why and give any information. Less than 5% of records should be to aggregated categories (and for the majority of surveys none).

In some years the number of Small and Green-veined Whites can reach exceptional numbers and it can be very difficult to see every individual well enough to record accurately to species level. In this case adopt a similar methodology as for Small and Essex Skipper, calculating a ratio of Small:Green-veined Whites to convert to species level records.

Further guidance on when to use these aggregated categories can be found in Table 2 in section 6 at the end of this document. Resources for identifying difficult species are in **Butterfly Identification Guide_2021 pdf**.

Bumblebee transects

Identify bumblebees within the 5m moving box to species where possible. Record caste (queen / worker / male) for social species, and for cuckoo bumblebees whether queen / male. Where species identifications are not possible (e.g. bee flies through the transect), use the colour grouping categories or ‘All bumblebees’ if need be.

Bees can be caught to identify them, using a plunger or sample pots. Stop the transect section while catching and identifying bees. Following identification, resume recording the transect section from the point at which it was stopped. Worn or melanic cuckoo bees can be difficult to identify – if needbe retain and freeze a sample (using a pan trap sample pot), then post it to Steven Falk for dissection and confirmation.

Table A1.4 below (under additional resources) lists species and caste identifications that should usually be possible. Colour group and additional identification guidance is in the **Bumblebee identification and colour groups guide_2021** document.

Floral resources

Floral resources are assessed as 'floral units' in two ways:
(a) in two 10 × 5m quadrats along each transect section, using a quick flower unit scoring system.
(b) in a 2m radius circular quadrat around each of the six pan trap stations.

Examples of floral units include a flower spike, umbel or flower head (Figure A1.3). A fuller guide to defining floral units (circled each photo) is provided with this protocol.

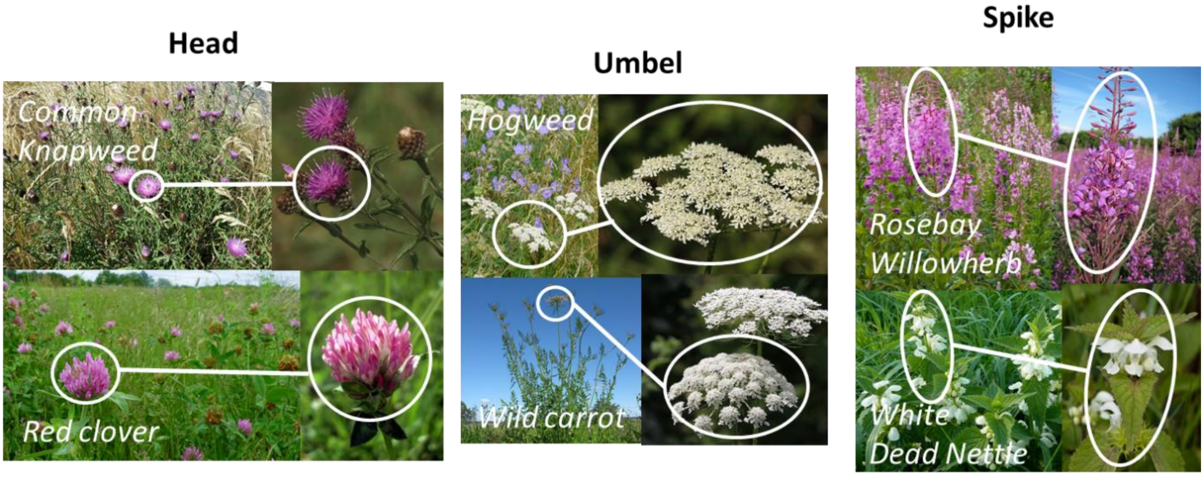


Figure A1.3 Examples of floral units, from PoMS target flower guide (Harvey et al., 2017)
Height of 10 × 5m and 2m radius circular quadrats – if a hedge face falls into your quadrat, assess floral units up to a height of 2m, but ignore any above that threshold.

4a) Quadrats along transect sections - scoring

Place the two quadrats roughly evenly spaced along each transect section length (approximately at 1/3 and 2/3 along length), covering the same width as the transect (include hedgerow face if it formed part of the transect).

Record abundance of all 'flower units' for each flowering species within each quadrat using a scoring system:
1 = 1 - 5 flower units
2 = 6 - 25 flower units
3 = 26 - 200 flower units
4 = 201 - 1000 flower units
5 = 1001+ flower units
6 = 5000+ flower units

If there are no flowers in a quadrat enter "Y" in the *No flowers* row at the top of the paper datasheet and access database, otherwise leave this row blank. If a whole square had zero flowers along the whole transect for a round, still enter a survey record (by filling in survey square, survey date, round number and recorder), and enter "Y" in the *No flowers* row for all quadrats.

4b) 2m radius circular quadrat around pan trap - approximate counts

Using the same definitions of floral units as above, count all the floral units of each flowering species within a 2m circular quadrat around each of the six pan trap stations using the following approximate counts: absolute counts for lower numbers (e.g. 1-10), to nearest 5 between 10 and 50, to nearest 10 between 50 and 200, and to nearest 50 above 200.

If there are no flowers in a pan trap quadrat enter “Y” in the *No flowers* row at the top of the paper datasheet and access database, otherwise leave this row blank. If a whole square had zero flowers for all six pan traps for a round, still enter a survey record (by filling in survey square, survey date, round number, recorder and pan trap details), and enter “Y” in the *No flowers* row for all six pan traps.

Collecting pan traps and recording failed traps / surveys

Return after a minimum of six hours, after you have walked the transect sections and recorded floral resources. Collect the pan trap stations in the same order as you set them. Empty your pan trap samples through a section of fabric into a funnel, so the invertebrates are retained in the fabric without the water. If any invertebrates are stuck in the pan trap bowls try rinsing them through with more water, or if need be, pick them up with a fine paintbrush. Do not pick them up with forceps or fingers as this can damage the specimens and make identification impossible.

Place the fabric and invertebrates in a labelled tube with 70% ethanol. Please put one (sticky) label on the outside of the pot, as well as paper label on the inside. Write the full square identifier (two letters, four numbers), date, pan trap number and survey round in pencil on both labels. Wear gloves when handling ethanol and refer to risk assessment and COSHH documentation. Invertebrate samples will be stored in alcohol, sorted to separate pollinator groups, and all bumblebee, solitary bee and hoverfly species identified subsequently in the laboratory. Collect the sample even if none of the invertebrates appear to be bees or hoverflies.

Record on the paper data sheet if there are no invertebrates in a working trap (Y = no invertebrates?, leave blank otherwise), and if the trap has failed for example if knocked over by livestock (*Failed trap?* Y = failed, N = working on collection). If more than one trap has failed tick the *Failed survey* box at the top of the data sheet and repeat the survey on another day.

If the whole protocol cannot be completed in 1 day in a survey square:
This protocol is designed for all data and pan trap sample collection to take place on one day in a survey square. This is in order to compare the bumblebee data across transects and pan traps, and so the floral resource data can be related to both butterflies and bumblebee transect data. This should be possible for the majority of surveys.

If this is not possible (e.g. due to availability of surveyors with specific taxonomic expertise or pan traps being overturned), ensure that all parts of the protocol are completed in any given square within 5 days, while still meeting the minimum weather requirements.

Additional resources and guidance

Recording bumblebees

For the majority of bumblebee species, it should be possible to identify most foraging bees to species and caste using the guidance given at training. Please record at this level where possible. The datasheet and database include a 'ND' (not differentiated) column. Table A1.4 on the next page gives guidance about when / for which species you may need to record in the ND column, or use a species aggregate. Please record queens separately in all cases, and all female cuckoos as queens.

A bumblebee identification guide is provided with this protocol (**Bumblebee identification and colour groups guide_2021**). Thank you to Steven Falk for permission to use his crib sheets.

Guide to identifying difficult butterfly species

A butterfly species identification guide is provided with this protocol (**Butterfly Identification Guide 2021.pdf**). Table A1.5., at the end of this document, gives guidance about which butterfly species can be recorded to aggregated categories where need be; please record to species if possible.

Guide to floral resource units

A guide to what constitutes a unit for floral resource assessments for common plant species is provided with this protocol (**FloralResourceGuide_AdaptedfromPoMS_2021**).

Table A1.4. Guidance for degree of species and caste differentiation while bumblebee recording along transects.

Species	**Categories for each species and when to use aggregated species**
Bombus 'lucorum'	Queen, male. Include *B. magnus* and *B. cryptarum*
Bombus terrestris	Queen, male.
Bombus lucorum-terrestris agg.	All workers of lucorum and terrestris. May also be needed e.g. for poor views of male terrestris. Use ND for undifferentiated male/worker if needed
Bombus hortorum	Queen, worker, male, ND for undifferentiated male/ worker
Bombus lapidarius	Queen, worker, male
Bombus pascuorum	Queen, ND for undifferentiated male/worker
Bombus pratorum	Queen, worker, male
Bombus hypnorum	Queen, worker, male, ND for undifferentiated male/worker
Bombus jonellus	Queen, worker, male
Bombus ruderatus	Queen, worker, male
Bombus soroeensis	Queen, worker, male
Bombus monticola	Queen, worker, male
Bombus vestalis	Female (record as queen), male
Bombus bohemicus	Female (record as queen), male
Bombus rupestris	Female (record as queen), male
Bombus barbutellus	Female (record as queen), male
Bombus sylvestris	Female (record as queen), male
Bombus campestris	Female (record as queen), male
Bombus humilis	Queen, worker, male, ND for undifferentiated male/worker
Bombus muscorum	Queen, worker, male, ND for undifferentiated male/worker
Bombus ruderarius	Queen, worker, male
Bombus sylvarum	Queen, worker, male
Group I - Browns	Colour group, use if species /aggregated species ID not possible
Group II Black-bodied red tails	Colour group, use if species /aggregated species ID not possible
Group III Banded red tails	Colour group, use if species /aggregated species ID not possible
Group IV Two-banded white tails	Colour group, use if species /aggregated species ID not possible
Group V Three-banded white tails	Colour group, use if species /aggregated species ID not possible
Other cuckoos	Use if cuckoo but unsure of species
Other bumblebees	Use if no other species / category possible, to ensure all bumblebees are recorded

Table A1.5. Guidance for when to use aggregated categories for butterfly recording on transects. Always identify to species if possible.

Butterfly species / category	**When to use aggregated categories**
Small/Essex Skipper	Only use where netting and calculating a ratio (see protocol) for species ID is not possible
Pearl-bordered/SP-b Fritillary	Use when you cannot differentiate between Pearl-bordered Fritillary and Small Pearl-bordered Fritillary; ID to species where possible
Dark green/High brown Fritillary	Use when you cannot differentiate between Dark Green Fritillary and High Brown Fritillary; ID to species where possible
Green-veined/Small White	Only use when either species ID or netting and calculating a ratio (see protocol) for species ID are not possible.
Other butterfly	Only use if no other category possible. Add note to give all identification information possible (e.g. white but could have been Large, Small or Green-veined white).

A1.3 Moth sampling protocol within 1km survey squares 2021

- Moth surveys will be undertaken **twice per year** at each survey square in each NCA, once in **May/June (round 1)** and once in **July/August (round 2)**. The UKCEH project team will specify dates for each round in each survey year; keep within these dates.

- Within each NCA all nine 1km squares should be surveyed within 1-2 weeks of one another, ideally on successive nights where possible. Allow at least three weeks between round 1 and round 2 of moth trapping for each survey square and randomise order in which survey squares are visited in each round as much as possible given access and weather restrictions

- Trapping should only be undertaken under suitable weather conditions as described below.

- Six individual moth traps will be employed in each 1km square and must all be run on the same night for a given square.

- Ensure all batteries are charged and the trap is functioning ahead of moth trapping – see Battery maintenance and care protocol.

Minimum weather requirements

It is important to optimize the conditions under which moths are surveyed. Cool, clear nights are unsuitable as are strong winds or heavy rain. Light rain is not a problem in terms of moth activity, but makes collection and storage of specimens more difficult so should be avoided where possible.

Moth surveys should be conducted under the following forecast conditions (see below for exceptions in upland NCAs)**:**

- Minimum overnight temperature of 10°C
- Maximum wind speed of 20km/h
- Maximum precipitation risk of 50% (if heavy rain forecast at any point in the night do not survey)

For squares in upland NCAs (Yorkshire Dales and Dartmoor) only, surveys can be conducted under the lower forecast temperature as follows, when and if this is necessary.

- Minimum overnight temperature of 8°C <u>IF</u> at least 2/3 of the night (hours between sunset and sunrise) are forecast to be at a minimum of 10°C.
- Do not trap if the temperature is forecast to be 7°C or less at any point during the night.
- Do not trap if >1/3 of hours between sunset and sunrise are forecast to be < 10°C.
- All other requirements (wind, precipitation risk, full moon) are as above.

Lunar cycle: moonlight reduces the effectiveness of light trap and potentially moth activity. Plan in advance to conduct moth surveys when the moon is within the first or third quarter of its cycle (New moon- half moon). The UKCEH project team will advise which weeks to target for each round. Do not trap for four days on either side of full moon unless there is sufficient cloud cover, conditions which may only be ascertained on the night itself. The following website can be used to check the lunar cycle:
https://www.timeanddate.com/moon/phases/uk/london

Fog: especially in upland areas or on squares near the coast fog may be an issue. Please check the weather forecast as late as possible and if fog is forecast overnight for more than one third of the time the traps are operational (sunset to sunrise) then please do not trap. Fog can be extremely local and the forecast may not always predict it, especially for the nearest weather station so it is also recommended to check while on site: if when setting traps up it is already foggy please do not trap. If when arriving in the morning there is fog/mist please make a note of this so we can factor this into analysis as moth catches are generally very low in foggy weather.

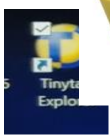
Recording temperatures to determine if survey needs repeating due to temperature

Especially in the upland NCAs the local weather stations used for weather forecasting may not be close enough to accurately predict local conditions. In addition, overnight temperatures can vary greatly depending on cloud cover which is sometimes less well predicted than other weather variables. For this reason Tinytag data loggers are provided to record overnight temperatures at trap sites. Information on how to use these is provided separately below. When setting up the moth traps hang a data logger at trap locations 1 and 4 on the post on which the moth trap is mounted (use the reusable tree ties given). When collecting in the traps the following morning collect in the data loggers.

Using the Tinytag data loggers

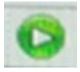
Software for tiny tags is on tablets or can be found on the surveyor USB. It is called Tinytag Explorer (if you need to load this to a different device please ask project team for activation code).

The yellow loggers, pictured to the right, are connected to device with the Tinytag cable (provided).



Open software Tinytag Explorer on the tablet (double clicking icon), then follow the step by step guide below:

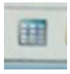
STEP 1 (Setting up loggers before deploying moth traps)

- On FIRST opening click green play arrow – this will launch the data logger. 
  + Description = Surveysquare_YEARMONTHDAY _1 or _2
  + Logging interval = Minutes Mode set to 30minutes
  + Start Options
    - Absolute start time = date moth traps to be set and 1hour before sunset[1] (as seen on weather check website)

+ Measurements = Temperature, minimum during each interval
+Stop options = Stop after 30 readings (i.e. 15hours)
+ Alarms = ignore!

STEP 2 (Downloading data from the loggers after collecting in the traps)

- After collection select *get data icon*  . A graph will appear showing the data – a quick look at this will determine if any temps have gone below threshold. You can zoom in to see more clearly.

- If temperatures do fall below threshold then click spreadsheet icon  which will bring up a spreadsheet with exact temperatures.
- **Highlight data from times between SUNSET AND SUNRISE[1] only** (if logger set correctly this should be close to the top of the list)
- Count the total number of cells (i.e. measurements) for the overnight period
- Count the number of cells when temperatures are below 10°C (8°C in the Yorkshire Dales and Dartmoor).

To determine whether to repeat a survey (see flowchart below):

- Divide the count of cells below the minimum temperature by the total number of cells and if it is >0.33 for both data loggers the survey needs to be repeated – inform a member of the project team.
- However, if one data logger passes this threshold (e.g. temperatures below the minimum for 30% of night time), and the second has temperatures below the minimum for ≤50% of night time, and lowest temperature is above 7°C (5°C in uplands), the survey is valid.
- If you do need to repeat a survey, leave these repeat squares until last in the current survey round – so if time runs out repeating surveys due to data logger temperatures are lower priority than surveying each square once, or repeating surveys if two traps are not working / knocked over by livestock.

- Save data.
  - Valid survey names = Surveysquare_YEARMONTHDAY_1 or Surveysquare_YEARMONTHDAY_2

[1] Sunset and sunrise times vary throughout the season and by location and should be checked online on the days traps were deployed and collected at the appropriate location each time

- Failed survey names = Surveysquare_YEARMONTHDAY_1_FAIL or Surveysquare_YEARMONTHDAY_2_FAIL

 Return to Launch data logger and repeat step 1 for next moth trapping session

STEP 3 (After completing moth survey round)

 At end of moth trapping round or when out of use for a few days select STOP or the battery will run out

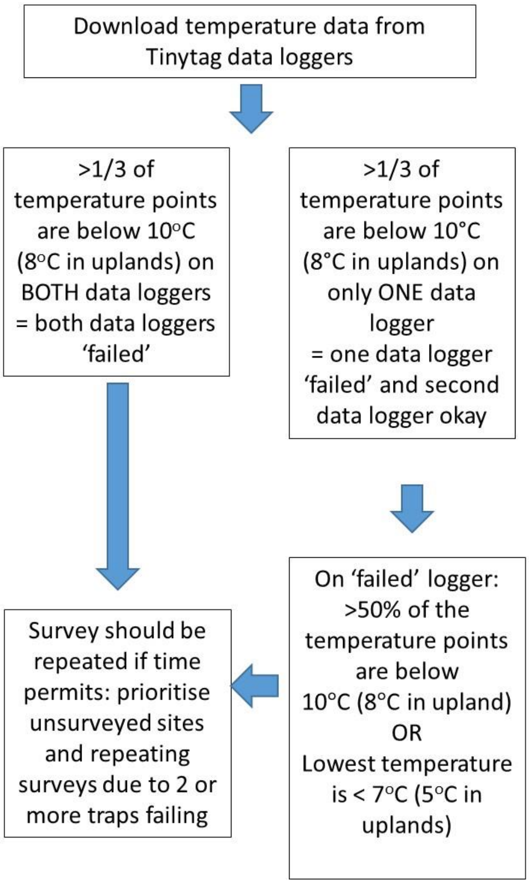


Figure A1.4 Flowchart to show when moth surveys should be repeated due to data logger temperatures

Powering the traps and charging batteries

Moth traps will be powered by portable 12V lead acid motorcycle batteries which weigh almost 3kg each. These should be carried in strong bags. This type of battery is unlikely to last 2 full nights on one charge and so should be re-charged daily or overnight using the provided chargers during the day while traps are not in operation. You have been provided with two sets of batteries so one set can be charged overnight while the second is being deployed with the traps. Refer to the Battery charging protocol and health and safety documentation (Risk assessment) for details on charging batteries safely within rented accommodation.

Re-locating moth traps

Six portable Heath light traps will be placed in each focal 1km square to sample moths, in the same position as the pan traps. For all survey squares, use the primary trap locations determined in previous years (see *2021_TrapLocationMap*). If you cannot use the primary trap location (e.g. if livestock present that are likely to interfere with the trap), use one of the alternative locations used previously in previous years, which are also listed on the square trap location map.

Deploying the moth traps

- Ideally traps should be set up as close to nightfall as possible, but the traps are fitted with light sensors so that they will only activate once it is dark. They can be deployed at the end of pollinator surveys so that a return to the square is not necessary if conducting pollinator surveys on the same day.
- Trap operational time is sunset to sunrise, so the latest the last trap in the square can be set is by sunset. Usually traps are set substantially before sunset, on very rare occasions they may be set closer to sunset if waiting for rain to stop. Allow yourself time to leave the site before it gets dark.
- When possible set the traps on the west-facing side of linear features to minimize morning sunshine, which can increase moth activity and cause moths to escape the light trap. Where this is not possible, position traps to minimize direct morning sunlight as much as possible and plan trap collection so that traps in non-sheltered positions are the first to be retrieved the following morning
- All traps should be placed 1-2 m from the edge of a boundary feature: in most situations this should be a hedgerow, but in some areas where hedgerows are absent or limited, use other boundary features.
- Where possible traps should be set up within a 20m radius of the pan traps used to sample pollinators, while also meeting the above placement criteria – the closer to the pan trap position the better, but this is not critical and the above placement criteria should always be met as priority.
- Attach the traps to the wooden stakes used to fix the pan traps with the bungee cords, so the traps are held in place and are the same level above vegetation height at each sampling point (as in the pan trapping protocol): the top of the bucket part of the trap should be just above the surrounding vegetation height or as near as possible.
- Make sure the traps are not positioned on any obvious pathways or animal tracks to reduce any interference once set. For example, if a trap is placed in an obvious badger ‘highway’ then it is likely to be disturbed during the night.
- Connect the light source to the battery and cover the batteries and crocodile clips with a strong carrier bag (supplied) to keep the rain off. Be careful not to knock the crocodile clips off the battery connectors during this.
- Ensure the light is working by placing your hand over the light sensor until the light switches on. Record on datasheet that you have done this.

- Record the time the trap is set in HH:MM format on the paper data sheet, and the number of the nearest transect section.
- Hang a Tinytag data logger on the stake along with the moth at traps 1 and 4 (make sure these have been set up correctly prior to deployment: see information on use of data loggers above)
- Only set traps on land where UKCEH has negotiated access permission, not on rights of way. Check the access permission map which shows the areas within each 1km survey square where permission is granted.
- Where moth traps are set further than 20m from the pan trap location conduct a floral resource survey within a 2m radius around the trap location, using the protocol for pan trap floral resources. If there are no flowers in the circular quadrat, write Y in the ‘No flowers’ row on the paper datasheet and make sure this is transposed into the Access recording database accordingly.
- When moth surveys are conducted more than 1 week earlier or later than a pan trap sample has been taken from the same location, floral resources within a 2m radius of the traps should be recorded regardless of location.

Trap retrieval and sample collection

Moth traps should be collected at sunrise the morning after they have been set. Please check the timing of sunrise for your local area and arrive there with plenty of time to walk to the first trap by this time. This timing is crucial, especially on warm and sunny mornings because the moths will start to leave the traps soon after dawn.

Equally important is not to collect the traps before the sun has risen since some species of moth will arrive at traps during the dawn period and/or will still be actively flying just prior to sunrise. Ensure you arrive at the first moth trap at first light, accounting for any time required to walk to the trap, and that traps are collected in as quickly and efficiently as possible, prioritizing those that are most exposed to morning sunlight.

Retrieving the traps

When arriving at each moth trap, the first steps are as follows:

1. Check that the light has been operational all night by covering the light sensor with your hand until the light comes on. If the light does not switch on check the connections to the battery and make sure they are still firmly connected. If the connections are still in place and the light still does not switch on the battery may be damaged. Please make a note of any trap catches where the light may not have been on all night and the reason why e.g. connections came loose or battery lost charge.
2. Remove the rain guard taking care not to shake the trap and disturb the contents within.
3. Remove the light source and baffles, again taking care not to disturb the trap (place these and the rain guards where you are not likely to stand on them or forget them, while you deal with the rest of the trap)
4. Place a tennis ball in the funnel entrance to ‘plug’ up the trap.
5. Disconnect the battery from the light source

6. Record on the paper data sheet whether the trap was operational when collected. To count as operational the light has to have been operational, and the trap has to still be intact (not disturbed by livestock or blown over).
7. Don’t forget to collect in the Tinytag data loggers from traps 1 and 4.

Moth trap survey failure

If a single moth trap is not working on collection, either because the light doesn’t come on when tested or the trap has been disturbed by livestock or blown over, the moth survey for that square can still be counted as a successful survey. In this case make it clear which trap failed (put ‘N’ in *Trap operating when collected row*), but leave the *Failed survey?* box blank.

If two or more moth traps are not working on collection, or the survey does not meet the minimum data logger temperature criteria above, the survey counts as a failure and must be repeated in the same round if at all feasible. In this case write N in *Trap operating when collected* for all traps that fail, and also tick the *Failed survey?* box at the top of the data sheet.

Failed surveys due to data logger temperatures are lower priority for repeating than failed surveys due to traps not working on collection. If you may not be able to repeat a failed survey in the round please ring the project team at UKCEH to discuss.

The next steps involve the collection of the moth samples. We are only interested in the moths inside the trap as those on the outside will vary from trap to trap in terms of how many fly off or are found by the surveyor.[2]

Collecting the moth samples

i. Preparing the samples for collection

Lethal trapping will be used so that all moths can be identified to species level and to efficiently survey the full 1km square in a single night. The chemical reagent, ethyl acetate (EA; see risk assessment and COSHH), used to anaesthetize the moths evaporates quickly and must be applied the following morning when collecting in the traps using the following procedure:

[2] Records of these ‘extra’ moths can be taken and submitted separately as long as this does not take long and the surveyor is confident in the identification, but will not form part of the data for this project. As 6 traps have to be visited as quickly as possible to avoid escapes do not spend more than 1 minute recording moths that are not inside the trap, and ensure this is done only once the trap has been plugged with the tennis ball so that no moths from inside the trap can escape.

1. Using a pipette apply 2ml of EA to a cotton wool pad[3].

2. Remove the tennis ball blocking the funnel entrance temporarily, place the cotton wool pad impregnated with EA into the trap and then replace the tennis ball immediately.

3. Make sure the lid of the moth trap is on properly and that the tennis ball is firmly in place and doesn't just roll out if the trap accidentally tips over, but also be careful not to push the tennis ball too hard as it will squeeze through the funnel entrance if forced. Then remove the trap from the stake and place on ground.

4. If there is any water on the lid either from dew or light rain during the night, gently tip the bucket to the side to make sure any excess water collected on the lid runs off. The traps are modified with a small foam ring to prevent this from going down the funnel but it is good practice to remove the excess water before dealing with the samples to reduce the chances of making the samples wet.

5. Move onto the next trap and repeat this procedure until all 6 traps have been visited.

6. Take the traps back to the vehicle.

ii. Packaging the samples

Leave a minimum of **3 hours** after placing the EA into the traps before collecting the moth samples. After 3 hours the moths and all other invertebrates can be emptied from the traps into some tissue and placed into the small white sample boxes provided as described below.

1. Before emptying the moths take a look inside the trap and if any still seem to be alive then add another 1ml of EA to the cotton wool pad and close the trap again and leave for another hour. It is very important that the moths are all dead before they are placed in the sample boxes as otherwise their activity results in the removal of scales and hair which makes identification extremely difficult and can result in the sample being unusable.

2. Carefully remove any large beetles (greater than 20mm, for example Cock-chafers, Summer chafers, Carrion beetles, large Carabid beetles and large water beetles) and any slugs or snails from the sample and place these in one of the white sample boxes provided. Large beetles take considerably longer to kill and are capable of destroying the more delicate moth samples; snails and slugs produce mucus which binds the samples together and again makes some of the sample difficult or impossible to identify – please make sure any slugs and snails in bycatch boxes are well wrapped in the provided tissue. However, since some of the smaller moths may be attached to these we need to retain these samples to check at UKCEH. These samples should be labelled in

[3] When using Ethyl acetate appropriate health and safety procedures should be followed as detailed in the Health & Safety documentation (COSHH): this includes wearing safety glasses, wearing gloves and goggles and carrying out the procedure in a well ventilated area.

the same way as the rest of the sample (see below and Figure A1.5) but additionally labelled as bycatch using the bycatch stickers provided (Figure A1.5). When entering the data for how many sample boxes there are for each trap on the access recording form, please put the number of boxes for bycatch separately in the row provided. Please note on recording forms whether or not a bycatch sample has been collected for each trap and if so how many boxes were used. If no bycatch sample is collected please note a zero on the recording form so we know not to expect a bycatch sample for that trap during that survey.

3. Now empty the rest of the catch from the trap into another white sample box.

4. The small white sample boxes provided for the deceased moths should never be more than 50% full as otherwise the moths will get damaged and become difficult to identify. Use multiple boxes for each trap as appropriate where catches are large.

5. Most species of hawk-moth, and some other larger moth species, may not fit in sample boxes, and if confident can be identified and recorded on the datasheet provided. There is an id guide towards the end of this protocol for such species. Please make sure that any moths identified and recorded in this way are not included in the sample boxes: these should be disposed of once they have been recorded.

6. In each sample box use 2-3 sheets of the tissue paper provided and lay out in bottom of box, such that the tissue can be folded over itself to retain the sample and minimize the chances of moths falling out through the slight gaps in the box joints (see Figure A1.5). Make sure the tissue is folded away from the open side of the box as this is where moths are most likely to be lost. Please do not use excessive amounts of tissue and ensure all the sample contents are within the folded tissue and not on the outside of it.

7. The final step before closing the box and labelling for each sample is to add a silica gel sachet. Place one sachet into each sample box. This is to help keep the samples dry and prevent mould since mould makes samples extremely difficult to identify, increases the handling time of samples and in some cases completely destroys some of the samples so they cannot be identified at all.

8. Make sure each sample box is clearly labelled with the trap number, square number and date using the labels provided: this is extremely important. **Use the date the trap was set** not when collected. Where there is more than one box used per trap label the boxes appropriately as one of the total number of boxes. For example, if three boxes are used, they should be labelled 1 of 3, 2 of 3 and 3 of 3 accordingly. Do this for boxes with 'moth' catches and 'bycatch' separately. For example, if you have 4 boxes for trap 1 and one of these is bycatch, the moth boxes should be labelled as boxes 1, 2 and 3 of 3, and the bycatch box should be labelled as box 1 of 1.

9. Write how many sample boxes you have used, for moths only, on the moth trap recording sheet in the appropriate row, to help with tracking samples.

10. Store the sample boxes in a freezer overnight if possible, wrapped in a plastic bag. Make sure there is no air in the plastic bag. This is to ensure all moths have died. Following this remove from freezer, take all boxes out of the plastic bag, and store in a cool, dry place.

11. Keep all sample boxes together in the provided sample storage boxes, preferably somewhere cool and dry out of direct sunlight. If the samples become mouldy they are very difficult to identify. Some moths are lost altogether, and many of the morphological structures required to separate similar species and many of the micro-moths, are destroyed. It is therefore essential to keep the samples as dry as possible.

12. Because it is not always possible to find a suitable location to store lots of samples in the provided accommodation we aim to pick samples up as and when possible. When this is not possible and/or there is an issue with storage we may ask you to post the samples to UKCEH. When this is the case please contact us at UKCEH where we will discuss the best method for postage. When sending samples please use the provided re-sealable blank labels to stick down the main box opening on each sample box to make sure they do not come open in transit, or more importantly to make sure small moths do not fall out if the samples are accidentally turned upside down in transit. Make sure the samples are packed together as firmly as possible to reduce the chances of them moving about in transit – for example fill any unused spaces in the parcel in which the samples are being sent with something like newspaper or bubble wrap.

13. If there are no moths in a sample, write Y in the ‘No moths’ row on the paper datasheet and access recording form. Otherwise leave this row blank.

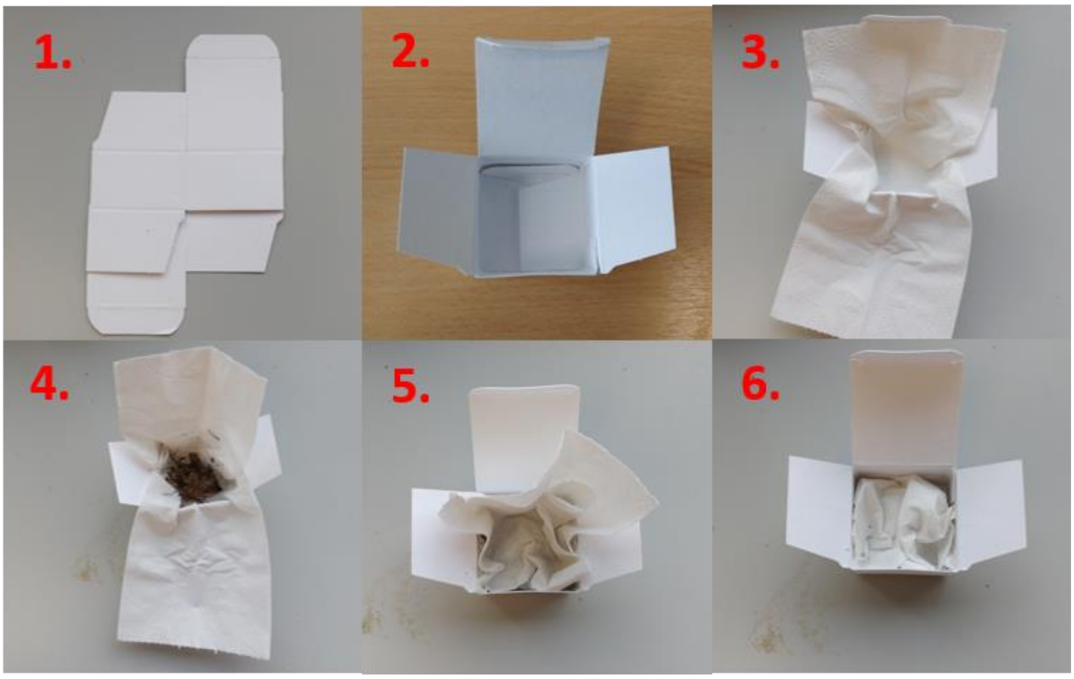


Figure A1.5 Procedure for packaging moth samples in sample boxes.

Data recording

Throughout this document there are various data that should be recorded as instructed such as whether traps have been successfully operational overnight or have failed. The following data also need to be recorded:

Weather data

Record shade temperature (e.g. with a portable thermometer placed in a shaded situation) and wind speed (using the Beaufort scale) when setting and collecting the traps. Also record the time set and collected.

Beaufort scale guide:

0	Calm	Smoke rises vertically;	< 1 km/h (<1 mph)
1	Light air	Slight smoke drift;	1-5 km/h (1-3 mph)
2	Light breeze	Wind felt on face;	6-11 km/h (4-7 mph)
3	Gentle breeze	Leaves in slight motion;	12-19 km/h (8-12 mph)
4	Moderate breeze	Dust raised & small branches move;	20-28 km/h (13-18 mph)
5	Fresh breeze	Small trees in leaf sway;	29-38 km/h (19-24 mph)
6	Strong breeze	Large branches move & trees sway.	39-49 km/h (25-31 mph)

Recording trap locations

Record the GPS coordinates for each moth trap within the square on every survey round if the location differs from the primary mapped trap location. If the trap has been located at the primary location on the trap location map, you can leave the GPS coordinates blank – we will assume all blank coordinates relate to primary locations.

Wait until the GPS accuracy reads 3-6m before recording the coordinates. Do not enter spaces, use capital letters and take some care as accurate GPS coordinates are essential to link the mapping and transect section/ trap data.

Survey date

Ensure the date you record on the moth data sheet and the moth sample label are both <u>the date on which you set the traps</u>. This is to ensure the moth survey and moth sample data can be correctly linked.

Moth trap equipment list

When putting out traps the following parts are all required for each light trap. Please make sure these are all collected in when collecting traps in as well.

1. Bucket
2. Lid
3. Funnel
4. Electric set with baffles and fluorescent tube
5. Tube insulation for protecting moth lamps – use to cover bulb at all times when the trap is not in use, including carrying around square
6. Rain guard
7. Clothes pegs for rain guard
8. Bungee cord
9. Battery
10. Bag for battery
11. 4 x egg tray quarters (1 large egg tray split into four pieces)
12. Wooden stake (with wing nut and wooden block)
13. Mallet
14. GPS
15. 2 x Tinytag data loggers (set and activated using a tablet, before heading to the survey square)
16. Reusable cable ties to attach Tinytag data loggers
17. Moth trap recording form
18. Folding ruler to measure area for floral resources

Additionally, when collecting in trap:

1. Tennis ball to plug trap
2. Ethyl acetate
3. Pipette
4. Protective wear: Gloves, safety glasses
5. Cotton Wool/tissue for applying ethyl acetate
6. Small cardboard boxes for moth samples
7. Moth sample labels for sample boxes
8. Moth trap protocol with guide for large species
9. Silica gel sachets

Extra equipment for charging batteries, spares

1. 12 x 12v lead acid batteries per set of traps - 6 labelled ‘A’, 6 labelled ‘B’ with Velcro cover over positive terminal
2. 6 x battery chargers
3. 1 x volt meter
4. Set of 2 screw drivers
5. Spare fuses

A1.4 Bird and Brown Hare survey protocol

Survey method

There are nine 1km survey squares per National Character Area (NCA). The bird and Brown Hare monitoring will collect data on (i) breeding bird numbers (counts of individuals or territories) and Brown Hare numbers and (ii) on bird use of AES options designed to provide winter food and winter Brown Hare numbers. In both spring (i) and winter (ii), three 1km transects will be walked per $1km^2$ sampling unit, with birds and Brown Hares sighted and heard within 100m either side of the transect route recorded onto maps of spatially-referenced transect sections variable length (similar to the BBS method but with three transects per square and transect sections not limited to 200m units). Locations of breeding season transects will be determined by where habitat along the route changes and will be fixed within each sampling square (same routes recorded on each sampling occasion), and will be sited approximately in proportion to AES coverage of the square (so if 10% of the square has AES, 10% of the entire 3km transect route passes by AES).

Site visits

- Breeding season: 3 × 1km transects per 1km square, 4 times per year from April to end July inclusive.

There are nine 1km squares to cover per NCA. If possible, two 1-km squares should be covered per morning so five to nine mornings of fieldwork each within the following four visit periods:

Breeding season 20 days @ ½ day per square; ~40 days at 1 day per square:
- April
- Early to mid-May
- Late May to early June
- Mid-June to mid-July

The data sheet format will be as below, with weather recording based upon that used for BBS:

Cloud cover		**Rain**		**Wind**		**Visibility**		**Ground conditions**	
0 – 33%	1	None	1	Calm	1	Good	1	Clear	C
33 – 66%	2	Drizzle	2	Light	2	Moderate	2	Frost	F
66 – 100%	3	Showers	3	Breezy	3	Poor	3	Snow cover	S
								Waterlogged/flooded	W

Bird data recording

Transect routes will be provided on OS maps, together with satellite photographs of each square to facilitate orientation and to identify the locations of individual transect sections. Each transect section should have a single habitat type on either side, typically defined by field boundary features or land-use. If you discover that any single transect section has more than one habitat then split the transect section and treat as two separate, re-numbered sections (e.g. Transect 8 would become 8A and 8B).

Each field, or discrete habitat, needs to be identified with a unique code (see Figure A1.6). Please use one of your maps to add and amend field codes and send a copy to Greg Conway to be updated.

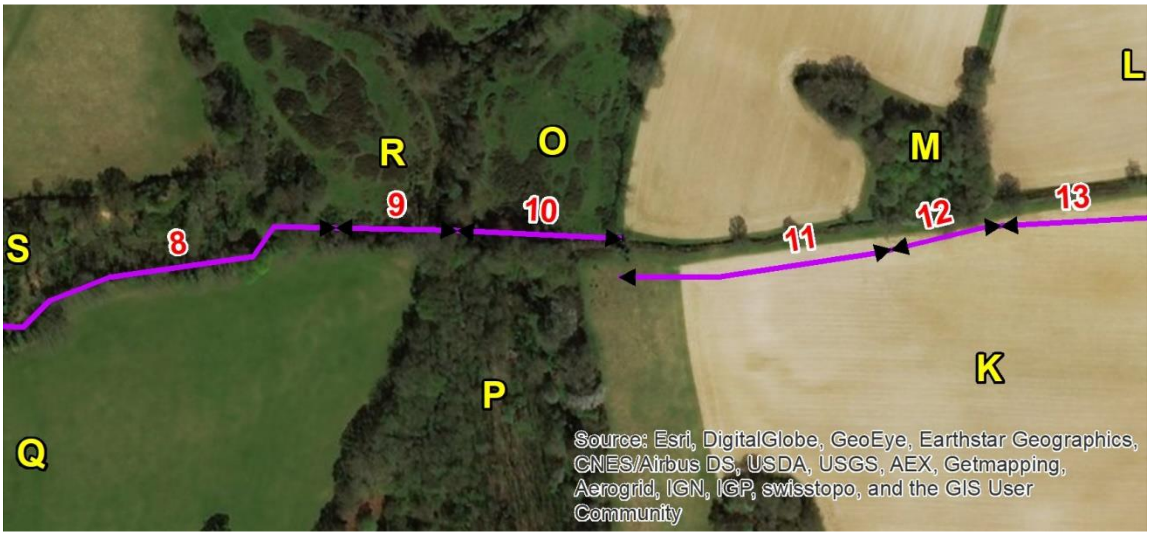


Figure A1.6 Example of a bird transect

Bird registrations (list of two-letter codes provided) should then be recorded onto the data sheets provided, by transect section and unique field code, separating birds detected by song versus by call or visually. To save time, birds should be recorded directly onto the data sheet an example of which can be found in Table A1.6.

Table A1.6 An example of the summer datasheet with bird and mammal records.

<table>
<tr><td>Observer</td><td></td><td>Square</td><td></td><td>Date</td><td colspan="2"></td><td colspan="2">Visit Number</td><td colspan="2"></td></tr>
<tr><td>Start time</td><td colspan="2"></td><td>End time</td><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td>Wind</td><td colspan="2"></td><td>Rain</td><td colspan="2"></td><td>Cloud</td><td></td><td>Visibility</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Transect section number</td><td rowspan="2">Species</td><td rowspan="2">Singing?</td><td colspan="2">0-25m</td><td colspan="2">25-100m</td><td colspan="2">>100m</td><td colspan="2">Flight</td></tr>
<tr><td>Tally</td><td>Total</td><td>Tally</td><td>Total</td><td>Tally</td><td>Total</td><td>Tally</td><td>Total</td></tr>
<tr><td>1</td><td>B.</td><td></td><td>|||</td><td>3</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>B.</td><td>Y</td><td>|</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>S.</td><td>Y</td><td></td><td></td><td>|</td><td>1</td><td>|||</td><td>3</td><td></td><td></td></tr>
<tr><td>1</td><td>S.</td><td></td><td></td><td></td><td>|</td><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>GC</td><td></td><td>|</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>LB</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>|||||</td><td>6</td></tr>
<tr><td>1</td><td>Hare</td><td></td><td></td><td></td><td>||</td><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>WR</td><td>Y</td><td>|</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Y.</td><td>Y</td><td>|</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>S.</td><td>Y</td><td></td><td></td><td></td><td></td><td>|||</td><td>3</td><td></td><td></td></tr>
</table>

Crop and land use recording

The majority of crops have already been mapped by UKCEH during the summer – 2 copies provided. During the winter visits you just need to check for omissions or changes in crop or field use and amend the maps as necessary (tick on the map or cross through and replace), using the categories listed below:

The primary habitats are:
Arable/Horticultural
Orchard
Improved grassland
Neutral grassland (semi-improved)
Neutral grassland (species rich)
Acid grassland
Calcareous grassland
Heathland
Fen, marsh and swamp
Bog
Broadleaved woodland
Coniferous woodland
Freshwater
Built up areas and gardens
Inland rock

Crop types are:
Spring cereal
Winter cereal
Spring OSR
Winter OSR
Beans
Peas
Sugar beet
Maize
Linseed
Miscanthus
Potatoes
Fallow/Stubble
Other (describe in notes)

A1.5 Bat monitoring methods

Rationale for the deployment of detectors

The bat monitoring protocol was designed to address the question of whether the abundance within local sampling units was affected by agri-environment scheme (AES) interventions at local and landscape scales. Large-scale deployment of static real-time bat detectors has produced realistic spatial patterns of bat occurrence and activity (Newson et al., 2017). With developments in passive bat detectors, software to aid the analysis of sound files and improving knowledge of species identification (Barataud, 2015), it is now possible to conduct representative acoustic assessment of bat species' distributions using presence-absence data and information on activity relative to habitats (e.g. Newson et al., 2015). The use of autonomous recording devices and standardised protocols for deploying detectors has proven potential to provide data that is comparable in quality to that collected by bat specialists but with logistical advantages for sampling complete and consecutive nights (Newson et al., 2015; The Norfolk bat Survey: https://www.batsurvey.org).

Survey methods

For the current LandSpAES study, autonomous, static real-time, full spectrum bat detectors (Wildlife Acoustics SM4Bat-FS detectors) were deployed under a new standardised protocol designed specifically to sample bat responses to AES rates at three scales: patch (within square), local (1km square) and landscape (3 × 3km) levels (Section 2.1). These new field survey methods were developed because the technology had not previously been deployed for these purposes at large spatial scales and with wide geographic representation. The paired detector design, helped to control for weather conditions that can affect bat activity (Barlow et al., 2015) as well as test for patch-scale effects on activity. This approach can generate a large volume of recordings, but the number of recordings can be highly variable depending on nightly weather conditions and local habitat. To address sampling noise, objectivity, replication and habitat representation was required.

Following the pilot results, the multi-night deployment per location was implemented in order to average out expected variation in bat activity due to weather, and also to increase the chance of detecting species that are present in the survey area at lower density, or that have a low detection probability. The likelihood of detecting a significant habitat association then also increases as the number of nights of recording effort increases within sampling occasion. Therefore, from the pilot protocol, the survey was designed around four sampling occasions, each of four or more nights, at each sampling point in each square. This field method was used in all six LandSpAES NCAs in years 2018, 2019 and 2021.

A1.6 Habitat resurvey protocol

Overview

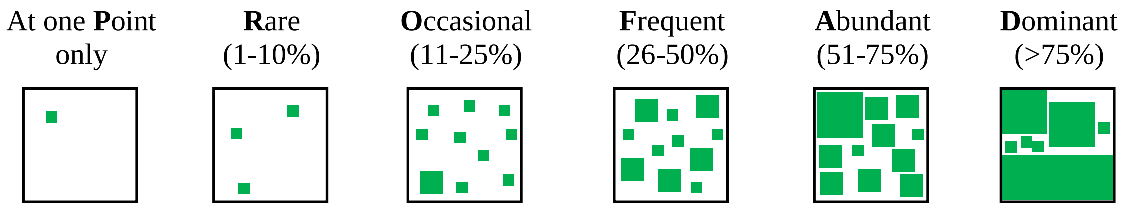
The aim of this protocol is to check the previous habitat mapping of surveyed squares which took place in 2017, 2018 and 2019. In particular, it is intended to fill in any gaps where parcels were left unrecorded, to update the crops for arable parcels, and to detect changes in habitats where necessary.

The purpose of habitat information is to determine the extent of habitats which may affect the impact of AES intervention on various species groups. We are not attempting to create a fully accurate map of habitats from ground survey but to validate and add detail to basic maps derived from satellite data.

Survey maps

- Each 1km square has an A3 paper map of the habitat data as surveyed in previous years, showing all previously surveyed habitat data in the form of colours and codes.
- Each habitat parcel should have a single code on the map, consisting of up to three parts:

- Many parcels will only have a **broad habitat** code – broad habitats are the most important aspect of this survey and reflect the major differences in land cover in agricultural landscapes. The list of two-letter codes for broad habitats can be found at the end of this protocol, and broad habitat descriptions and key are available in accompanying documents
- **Secondary habitats** record additional habitats features which are likely to influence the impact of AES on key taxa but which fall outside the definitions of the broad habitats. The list of two-letter codes for secondary habitats can be found at the end of this protocol
- If a secondary habitat is present, the **secondary habitat cover** code refers to cover as estimated via the DAFOR scale (see overleaf)



- So, the example code given above (IG_UV_A) refers to improved grassland (IG) with Unmanaged Herbaceous Vegetation (UV) at Abundant (A) levels of cover
- Any **numbers** next to codes refer to notes from previous surveys which are provided on the right hand side of the map

- Note that the legend to each map shows only those broad and secondary habitats previously detected on the square. If you need to add a broad or secondary habitat other than these, please refer to the full list of codes at the end of this document
- Draft copies of the maps are provided so that multiple surveyors can map different areas. These are clearly marked as drafts and all data must be transferred to the master copy once mapping is complete

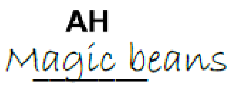
Protocol

1. **Add your name and the survey date to the map**. This is very important and helps us know where to address any clarifications.
2. **Visit every mapped parcel** where safe to do so, especially those not previously recorded, and ensure that all parcels visited are marked as follows:
    - If the entire code is correct, circle it (ideally using soft pencil or fine black marker pen)

    - If all or part of the code is incorrect, strike it though and write the updated code next to it

    - Add codes to any parcels missing in previous surveys (coded **X** and shaded in red) in the same way

    - For arable parcels, write the crop name in full below the habitat code (lines are provided as are reminder). If you add a crop you don't need to circle the AH code, we'll assume it's correct. If you don't know the crop, add the best description possible (e.g. 'winter wheat' is best, but 'wheat' or 'cereals' are still helpful).



3. **If the extent or shape of a parcel has changed**, or needs subdividing, draw it on the map, write the required habitat code within the new parcel and add a numbered note. Space is provided for up to three notes, but more can be added on the reverse of the map.

1. New housing estate in NE corner

When considering whether to mark a change, bear in mind:

- Do not add parcels less than 0.25 Ha in area. Minor changes in the extent or shape of habitat parcels that are more likely to arise from differences in surveyor opinion than genuine change should be ignored
- Do not add linear features (roads or rivers) that are not already mapped
- Broad habitats are very likely to remain as previously mapped. Exceptions may include change between arable and improved grassland as part of crop rotation, from semi-improved to species-rich grassland as part of AES restoration, or construction of new built up areas
- Secondary habitats are more likely to have genuinely changed. Examples include growth or clearance of scrub, bracken or herbaceous vegetation. Changes in type or cover of secondary habitats should be recorded, but only where there is a strong probability that these reflect real changes rather than differences in observer opinion
- Many upland habitats are extensive and complex, and secondary habitats have often been used to reflect mosaics of acid grassland, bog, heath, etc. Do not change these unless you think real change has taken place or the previous mapping is entirely in error
- Do not add multiple secondary habitats

4. **Notes from previous surveys are provided** because they sometimes contain important safety information (e.g. presence of uncapped mines and sinkholes) or explanation of complex habitats. You do not need to check whether they are still correct, just use them to aid surveying. You can also add your own numbered notes to explain changes (as shown above).

5. **Do not record AES options** (e.g. field margins and corners) on these maps – these are mapped separately

6. Finally, check that you have **named and dated the map** and that **all codes on the map have been either circled or edited**. If any are left blank we have to assume that they were not surveyed

7. In general, try to think about the **simplest way** to record the **habitats of greatest likely interest to the species we're monitoring**. That's the approach which should have guided the previous surveyor. Do use secondary habitats codes and crops to record additional detail where necessary, and use numbered notes to explain (concisely!) any changes. But don't worry about minor changes or excessive detail.

Habitat codes

Broad Habitats

- **X**: Not recorded
- **AG**: Acid grassland
- **AH**: Arable/Horticultural
- **BG**: Bog
- **BW**: Broadleaved woodland
- **BU**: Built up areas and gardens
- **CG**: Calcareous grassland
- **CW**: Coniferous woodland
- **FM**: Fen, marsh and swamp
- **FW**: Freshwater
- **HE**: Heathland
- **IG**: Improved grassland
- **IR**: Inland rock
- **NI**: Neutral grassland (semi-improved)
- **NR**: Neutral grassland (species rich)
- **OC**: Orchard

Secondary Habitats

- **AG**: Acid grassland
- **BA**: Bare ground
- **BR**: Bare rock and scree
- **BG**: Bog
- **BK**: Bracken
- **CX**: Complex mosaic
- **DS**: Deciduous scrub
- **DW**: Dwarf shrub
- **GO**: Gorse
- **JC**: Juncus spp.
- **LP**: Limestone pavement
- **ST**: Scattered trees
- **UV**: Unmanaged herbaceous vegetation
- **UF**: Upland flush
- **WA**: Water

Secondary habitat cover

D = Dominant = >75%
A = Abundant = 51-75%,
F = Frequent = 26-50%
O = Occasional = 11-25%,
R = Rare = 1-10%
P = Present = <1%

A1.7 Option mapping protocol

Overview

The aim of this protocol is to amend the option mapping of surveyed squares which took place in 2017 2018 and 2019. In particular, it is intended to update locations of rotational options, record the establishment of new options and ensure that all options have been mapped correctly.

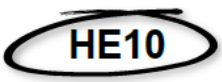
Survey maps

- Each 1km square has a paper map of the option data as surveyed in 2017 and/or 2018, with all options displayed and labelled with their option code.
- Linear options (e.g. hedgerow and ditch management) are magenta, whilst options covering areas (e.g. margins, patches, whole fields) are purple hatching.
- The options present in the square are also listed to the right hand side of the map, along with a description (note that descriptions may be abbreviated from the full descriptions in AES documentation). Option codes are
- Some "non-scheme" options have been and can be recorded on the maps. These are:
    - GCM = Game cover - maize
    - GCC = Game cover - cereals
    - GCB = Game cover - kale
    - GCO = Game cover - other (quinoa, millet, etc)
    - NSGB = Non-stewardship grass buffer
    - NSFC = Non-stewardship field corner
- Draft copies are provided so that multiple surveyors can map different areas. These are clearly marked as drafts and all data must be transferred to the master copy once mapping is complete

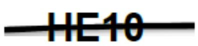
Protocol

1. **Add your name and the survey date** to the map. This is very important and helps us know where to address any clarifications.

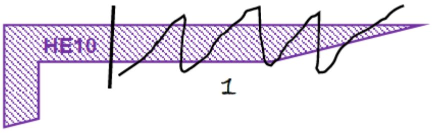
2. **Visit every mapped option** where safe to do so and ensure that all options visited are marked as follows:
    - If the option code and location are correct, circle the code on the map (ideally using soft pencil or fine black marker pen)



    - If the option has been entirely removed, strike through the option code on the map



    - If part of an option has been removed, amend the map and add a numbered note. There is space for five notes to the side of the map, but more can be added on the reverse if necessary

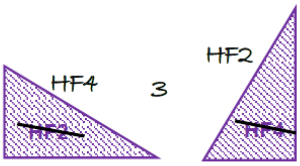


1. Part of North HE10 margin removed

- If a new option has appeared, draw it on the map as accurately as possible, write the required option code within/next to the new option and add a numbered note. For new options, please ensure their width is recorded if they are linear or a margin.

2. New EF2 patch in South West corner of field

- Some rotational options may simply swap places. In this case, strike through the code for both options and add a new code adjacent. You may add a note to clarify if necessary



3. These two patches have swapped options

3. **Do not attempt to record option condition** on the map. If an option has clearly been implemented as mapped, but is entirely or partially in poor condition, simply verify that the option code is correct

4. Identifying options in the field can be difficult, and in some cases impossible (e.g. supplements). It is best to consult the background maps and any additional information from the landowner on option placement before attempting to map options.

5. **Do not record habitats** (e.g. patches of woodland, buildings) on these maps – these are mapped separately.

6. Finally, check that you have **named and dated the map** and that **all codes on the map have been either circled or edited**. If any are left blank we have to assume that they were not surveyed.

A1.8 Botanical protocol 2021

- This is a one-off botanical assessment along transect section routes, to collect additional plant species data beyond the floral assessments which are done as part of transect and pan trap surveys.
- Cover of all higher plants species will be recorded in five 1m^2 quadrats placed along each transect section, as detailed below. A walk over will be used to record additional higher plant species not recorded in the quadrats.

Timing

This botanical survey can take place at any time during the field survey (May – early September), and there are no weather constraints. Different transect sections within a survey square can be assessed on different dates. Ensure you record the survey date for each section as date will be included in the statistical analyses.

Quadrat placement

Place the five quadrats in a zig zag formation along the length and 5m width of the transect section, avoiding 5-10m at each end of the transect which may be atypical. The zig zag formation should be used to cover both edges of the transect section width, as well as the middle of the transect width, and quadrats should be approximately evenly distributed along the transect section length (avoiding the ends; Figure A1.7).

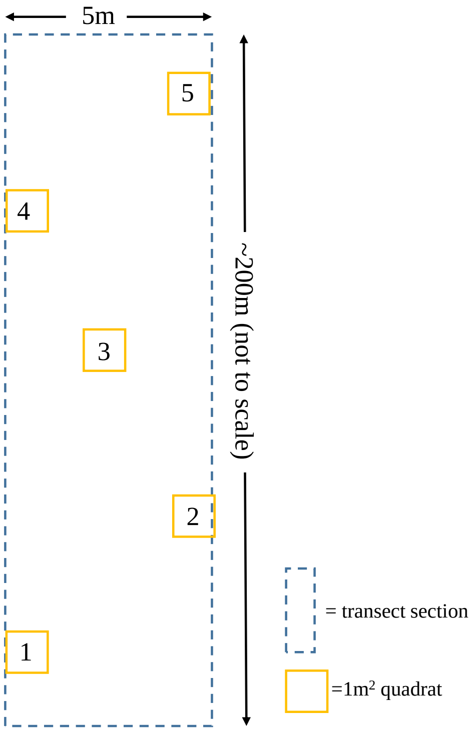


Figure A1.7 Placement of quadrats along a transect section, note transect length not to scale.

Crop edges – if the 5m transect width includes crop, place two of the quadrats to sample the crop, but avoid standing on or walking on the crop (Figure A1.8a).

Hedges – if the transect runs alongside a hedge and includes the hedge face, place two of the quadrats half under the overhanging hedgerow foliage, so they sample some of the hedgerow basal flora as well as the adjacent margin vegetation (Figure A1.8b). It may be easier to use 2m folding rulers for three sides of any quadrats under a hedge, than trying to get a rigid quadrat under a hedgerow (Figure A1.9).

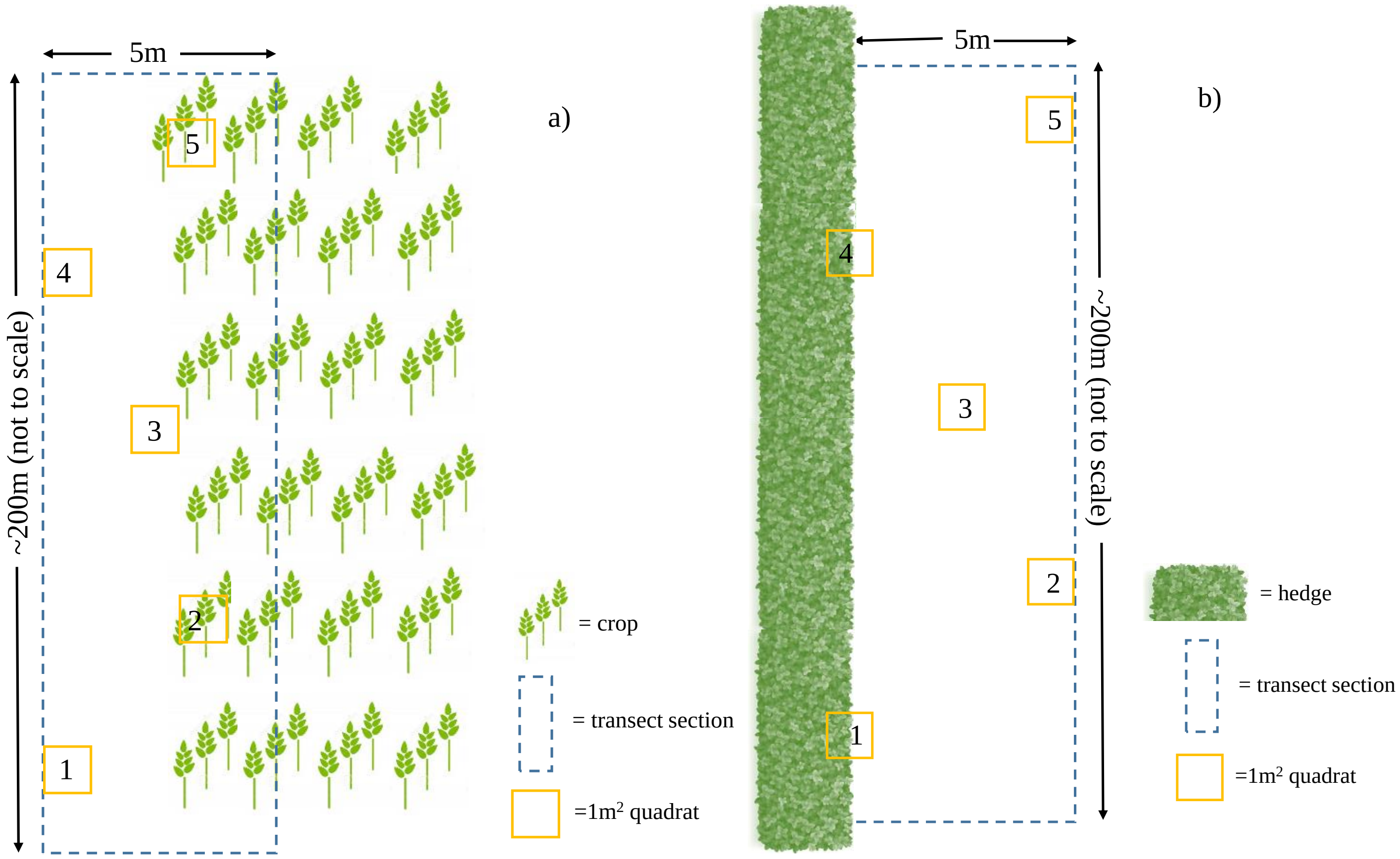


Figure A1.8 a) Quadrat placement to avoid walking in crop for quadrats 2 and 4. b) Quadrat placement for a transect section including hedge face. Some hedgerow basal flora included in addition to margin vegetation in quadrats 1 and 5.

Figure A1.9 Examples of quadrat placement under hedgerows.

Recording vegetation in quadrats

Record percentage cover of each higher plant species as <1, 2, 3, 4, 5, 10 and then to nearest 5%. Also record percentage cover of bryophytes (as a group), bare ground, leaf litter and rock.

Include woody vegetation overhanging quadrats, up to a height of 2m. Percentage cover may sum to more than 100% due to layered vegetation, especially in quadrats which include overhanging woody species.

Walk over

After finishing the five quadrats walk along the transect section noting presence of additional higher plant species not recorded in any of the five quadrats, especially woody and semi-woody hedgerow species. This should be a quick walk over to record additional prominent species, not a census of the entire transect section area.

Data recording

Data can be recorded either directly onto the tablet botanical database, or onto the paper datasheet and entered later into the botanical database on your tablet.

A1.9 Agri-environment scheme option implementation monitoring

- Agri-environment scheme (AES) options are assessed in 2017 and 2018, the majority in the summer. Any which need to be assessed in winter will be covered by BTO surveyors.
- There are no minimum weather requirements and timing is less critical than for the invertebrate monitoring, with the exception of flower counts which are done in June/July (see below). Fit them in on bad weather days around the higher priority invertebrate monitoring, and if needbe leave them to September.
- Some options assessed in 2017 on survey squares in lowland NCAs only need a partial resurvey in 2018; further guidance in B below.
- This protocol provides general information on quadrat placement and recording, measuring sward height etc (section C), a floral resource assessment to be done across all options in 2018 (D), followed by the specific protocols for each group of similar AES options (E).

Database structure

AES option implementation data will be recorded directly into a database on tablets computers. There are around 20 recording forms covering over 100 options. The form to be used for each option is listed on Options_AESImplementationRecordingForms spreadsheet (provided as two A4 sheets), and options are also listed on the top of each database form, as well as on the individual protocols below. All protocols are underpinned by recording botanical data in five $1m^2$ quadrats; recording forms differ in questions to be answered and the additional data to be recorded.

Do not leave multiple forms open at the same time when recording into the database. Record into one form, finish entering data, press the save and close button before entering into another form.

If you open a form by mistake and start typing in data by mistake, write ‘ERROR’ in the notes, and make a note of the record number (the bottom of two record numbers), as you may not be able to delete this record. When submitting your final database to CEH, send in a list of any records to be deleted to the project e-mail (AESspeciesmonitoring@ceh.ac.uk).

Database backup and submission to UKCEH

Before recording, save a copy of the blank AES_Implementation Access database with the date and your initials as a suffix into the “Recording data” folder on your tablet. Record all implementation data into this database, changing the date in the database file title on each day you record into it.

Create a copy of this AES implementation database and save in the “daily data backup” folder on your tablet at the each of day you add data to it. Continue recording into the same database in the “Recording data” folder on the next day you assess implementation (not into the daily backup copy or a new blank database).

Load a weekly backup of the most recent copy of your database onto the Wiki each week.

At the end of the field season CEH would like one database with all your AES implementation data recorded into it. This will be the last weekly version you submit. Add the suffix FINAL to this last version in addition to your initial and the date. Ensure that you are adding all data to the same database, not starting a new database each day or week.

Agri-environment options to survey in 2018

Do not include supplementary options in implementation assessments (e.g. OU1 organic supplement, HR1 cattle grazing supplement), see Options_AESImplementationRecordingForms.

Survey square in upland NCAs (Dartmoor and Yorkshire Dales)

Every type of option mapped (those listed on square option map plus any additional options marked on agreement maps or located on the ground which you have mapped) should be surveyed for implementation, excluding supplementary options. Options_AESImplementationRecordingForms lists all options codes with the form to use for implementation assessment. In addition, all options will have a floral assessment (D below) which is on a separate recording form in the AES implementation database.

Survey square in lowland NCAs surveyed in 2017

- All options surveyed in 2017 will have an additional floral assessment in 2018. This is on a separate tab in the database ("Floral"), further details in D below.
- All sown and arable options surveyed in 2017 will be resurveyed using the full protocol – e.g. headlands for arable plants, pollen and nectar mix, winter bird food plots.
- Buffer strips and grassland options will not be resurveyed in 2018, apart from the floral assessment above.
- Hedgerow options will be partially resurveyed, see guidance below.
- If any new options are mapped, do a full implementation assessment for these options, regardless of which category they fall into.
- If any options were not implemented in 2017 (e.g. in new Countryside Stewardship agreements) but are now visible, do a full implementation assessment.

The Options_AESImplementationRecordingForms spreadsheet lists whether an option in a lowland square should be resurveyed in 2018 entirely, partially, or only for floral resources.

General instructions for implementation recording

How many options to cover in 1km survey square and how to prioritise?

Often it will be possible to survey all instances of all AES options within a survey square (e.g. all nectar flower mix plots) shown on your option map. Include those options targeted at birds in your implementation monitoring, as well as invertebrates.

In a few survey squares hedgerow management and grass buffer strip options may extend around all sides of many fields, or there are many examples of a single grassland option. If more than 5 examples of an option are present, survey at least 5 examples of the option. If not surveying all examples of an option, prioritise which 5 to survey following these guidelines:

Survey as many fields as possible. For example, if there are 8 fields with the same grass buffer option, survey one example of this option in each of 5 different fields.

If there are few fields with the same option all the way around each field, survey multiple margin / buffer strips in one field. For example, for a square in the Fens with two large fields each with HE10 around all the field boundaries, survey two HE10 in one field and three in the other.

If choosing between examples of a single option, survey those that run adjacent or close to transect sections.

Recording option location information at start of survey

Record the survey square number, agreement number and option code. These are preloaded into the database, and all squares should be listed in 2018. If you are surveying a square that is not in the drop down, use the AddSurveySquare form to add it. Close all other forms before adding a survey square. Do not add multiple instances of the same square using the AddSurveySquare to the drop down menus.

Record the GPS coordinates around the centre of each option on your data sheet. Wait until the GPS accuracy reads 3-6m before recording the coordinates. Please take some care as accurate GPS coordinates are essential to link the mapping and option implementation data. You must enter GPS coordinates before you can save and close a new option record in the database.

Also record the field number the option is in (refer to the agreement documentation for pdf map showing field number), and for boundary options, which boundary it is near (e.g. N, SW etc).

Placing your quadrats

Botanical recording is in $1m^2$ quadrats, with five quadrats assessed per parcel / patch / margin under AES option management. On linear options (margins, headlands) space the five quadrats approximately equally. On whole parcels or patches, space the quadrats out along a ‘W’ walk to cover the whole area.

On ditches and hedgerow options, quadrats will be placed on the permanent vegetation associated with the boundary (not the woody hedgerow itself). Place ditch quadrats as close to the ditch lip as possible, and hedgerow quadrats close to the edge of the hedgerow.

Recording botanical data and percentage cover

On all but three of the forms, forbs and sown species percentage cover will be recorded by species and grasses in categories. The instruction at the top of these database forms reads "Record percentage cover of all forbs and sown species to species, and grasses in categories, in five $1m^2$ quadrats". Do not record grasses to species on these forms (this wastes time in the field and makes data processing more complex).

For some protocols sown species expected by Natural England will autofill when you hit the add quadrat data button, in addition to the grasses in categories. This is just a prompt to look out for these sown species. If they are not present leave the quadrat data blank, and record cover of each other forb species that is present.

Grass cover is recorded as percentage cover of tussocky grass, fine grass and cover of total grass. Tussocky grass is defined by grass structure rather than grass species, and is estimated to assess the range of microclimates provided for invertebrates. Estimate the percentage cover of grasses that are growing in clumps or bunches which are usually raised in height relative to the rest of the sward. Examples of tussocky grasses in margins are shown in the photos below.



FERA advise that the species below (Table A1.7) are likely to be growing in tussocks; this may be useful guidance. For our project the definition is by structure not by species, as for example *Dactylis glomerata* could be present as seedlings or in a tightly grazed sward that does not count as a tussock. Use these species as a guide, but base your assessment on the physical structure of the grass present.

Agrostis curtisii	Bristle Bent
Alopecurus pratensis	Meadow Foxtail
Ammophila arenaria	Marram
Arrhenatherum elatius	False Oat-grass
Brachypodium pinnatum	Tor Grass
Bromopsis erecta (Bromus erecta)	Upright Brome
Dactylis glomerata	Cocksfoot
Deschampsia cespitosa	Tufted Hair-grass
Deschampsia flexuosa	Wavy Hair-grass
Festuca arundinacea	Tall Fescue
Festuca pratensis (Schedonorus pratensis)	Meadow fescue
Lolium multiflorum	Italian Ryegrass
Molinia caerulea	Purple Moor-grass
Phleum pratense	Timothy

Table A1.7 Grass species which may form tussocks

The summed percentage covers of all forb species and grass categories can exceed 100%, as the vegetation may be present in layers. Percentage cover of a single category of grass cannot exceed 100%.

Measuring sward height (vegetation structure).

Record 20 measurements per option: one per quadrat plus additional measurements between quadrats, roughly evenly spaced. Use a Perspex ruler against measuring stick (cm gradations) and record the highest point of the Perspex touching vegetation - green leaves only, not flower stalks or litter.

On the sward height tables in the database recording forms enter 1-20 in the column titled Replicate as well as entering the heights.

Recording evidence of cutting

Record as recent / not recent (substantial regrowth) / none

Recording aspect

Aspect – direction you are facing with your back to feature

Eligibility / prescription criteria

For the eligibility and prescription criteria listed, record if there is any evidence they are not met (click 'yes' if you see evidence the criteria are not being met).

Record no to 'evidence of not being met' only if you can be certain the criteria is met, for example 'Only on arable land, temporary grassland and bush orchards'.

In some or many cases you will not be able to assess the criteria, depending on time of year and the specific question. Leave blank those you cannot assess.

Recording form Notes tabs

Record any additional relevant information about the option, but please keep these brief.

Recording form fields with suffix id (e.g. SurveyID, GrassBufferStripID, NotesID)

These will autofill, do not enter anything here.

Floral assessment 2018

All options within each survey square need to have a floral assessment in 2018, which is on a separate tab in the AES Implementation database. For the majority of options this assessment should be done in June or July, see below for exceptions. In 2018 this is likely to be mainly in July, due to moth survey round 1 in June. For lowland squares, use the 2017 implementation map for each square to help relocate the options surveyed in 2017.

Record in five $1m^2$ quadrats within each option, placing the quadrats as described above in C3. If half the option has been cut (as advised for some arable options), do the floral assessment in the uncut section.

For each flowering forb species, assess the number of flower units in the quadrat approximately using the index below. Define a floral unit for each species using the floral resource guide (FloralResourceGuide_AdaptedFromPoMS_2018).

Number of flower units per m2 (assessed for each flowering species separately)

1-5	1
6-10	2
11-25	3
26-50	4
51-100	5
101-250	6
251-500	7
500+	8

On the **notes tab record evidence of recent cutting** for the option you are doing the floral assessment in as one of: recent / not recent (substantial regrowth) / none.

For hedgerow options, place the $1m^2$ quadrats against the hedge face. If hawthorn or blackthorn have flowered earlier in the year, assess the number of berries / sloes in the quadrat using the same index as above.

If there are no flowers, enter the header information, record evidence of recent cutting, and write “0 flowers” in the notes tab.

Timing exceptions for floral assessments:

1) Sown arable options assessed using these protocols/ recording forms: Winter bird food, Nectar flower mix, Autumn sown bumblebird, Sown legume fallow.
Assess in June-August, roughly target peak flowering of dominant species.

These are temporary sown options often rotated after 2-3 years, and may be sown in spring or autumn. If the option is in the first year after a spring sowing, establishment may be delayed so peak flowering is later in the summer. In the second year of these rotational options, flowering may peak in June for some biennial species. Peak flowering will also be affected by the weather in any given year. Try to target the floral assessment around peak flowering for dominant species if possible.

2) Upland options assessed using these protocols/ recording forms: Upland enclosed rough grazing < 15ha, Upland moorland and rough grazing options – often unenclosed.
Assess in June-August, roughly target peak flowering of dominant species.

Dominant species on these upland moorland and rough grazing options may be flowering later in summer, for example some heather species flower July – September. Try to target the floral assessment around peak flowering for dominant species where possible. This may require assessing different broad habitats under the same option at different times (see E18, E19 below).

If you have already assessed upland options before peak flowering in second half of June 2017 under the previous guidance, please do not go back and redo them.

Roughly targeting peak flowering shouldn’t result in a need to visit squares multiple times on specific dates, that degree of accuracy is not needed. Flowering will peak at different times for different species, so try to target the dominant species where possible, but as this is a one off assessment it is inevitable that some species will flower before and after the assessment. All squares are visited at least once a month, so if there are a couple of options where floral assessments are later or earlier than the rest of the implementation work, try to fit them in when you are visiting that square anyhow if possible.

Other upland options which are not recorded on either of these two forms (e.g. in-bye grassland options recorded on PermGrassland_LowInput form, species-rich grassland options recorded on Grassland form) should have their floral assessments done in June or July as previously advised, as should all other lowland options.

Protocols by option group(s)

1) BufferStrip_CultivatedLand, BufferStrip_IntensiveGrassland, BufferStrip_Watercourse, BufferStrip2m, InFieldGrassStrips, DitchManagement

Recording form name in database	**Options**
BufferStrip_CultivatedLand	SW1 EE2 EE3 HE2 HE3 OHE2 OHE3 OE2 OE3
BufferStrip_IntensiveGrassland	SW2 EE6
BufferStrip_Watercourse	SW4 EE9
BufferStrip2m	EE1
InFieldGrassStrips	SW3
DitchManagement	EB6 EB7 HB14

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground.

Grass buffer strip tab - Record sward height at 20 positions across the option as described in general guidance above.

Record the type of boundary feature the buffer strip runs along (list on recording form).

Record whether there is evidence of cutting (recent / not recent / none), not recent = cut this year but substantial regrowth.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

The ditch management form does not have questions as this option has not been carried forward into the new Countryside Stewardship AES. The evidence of cutting question is on the grass buffer strip tab for this form. Place quadrats on the permanent vegetation associated with the ditch, as close to the ditch lip as possible.

2) Nectar flower mix

Recording form name in database	**Options**
NectarFlowerMix	AB1 EF4 HF4 OHF4

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground. Some potential sown species will autofill in the species list along with the grass categories; this is a prompt to look out for these and not an exclusive species list.

The option guidelines suggest cutting this option up to 4 times in the first year, which will affect flower production. In second and subsequent years, half the area should be cut before the end of May. Quadrat assessments should be carried out in the uncut half, if this can be distinguished at the time of assessment.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = evidence not being met); leave blank if no evidence either way.

Record the evidence of poaching as for grass buffer strips above.

Record whether there is evidence of cutting (recent / not recent / none), not recent = cut this year but substantial regrowth.

Record the aspect in relation to adjacent boundary feature, with your back to the boundary feature.

Presence of overhanging trees – record an estimate of the % of strip with overhanging trees.

3) Flower rich margins and plots

Recording form name in database	**Options**
FlowerRichMargins	AB8, HE10, EE12 (EE12 is a supplement to buffer options, may be hard to locate if not implemented well)

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground. Some potential sown species will autofill in the species list along with the grass categories; this is a prompt to look out for these and not an exclusive species list.

Buffer strip and boundary tab - Record the sward height as for grass buffer strips above.

Record whether there is evidence of cutting (recent / not recent / none), not recent = cut this year but substantial regrowth.

Record the type of boundary feature the flower rich margin option runs along (list on recording form).

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = evidence not being met); leave blank if no evidence either way.

Record aspect and presence of overhanging trees as for nectar flower mix above.

Record evidence of poaching or compaction.

4) Winter bird food

Recording form name in database	**Options**
WinterBirdFood	AB9 OP2 EF2 HF12 HF2 OHF2

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground. Some potential sown species will autofill in the species list along with the grass categories; this is a prompt to look out for these and not an exclusive species list. Some of the sown species are crop species and graminoids, for these percentage cover should be recorded to species level, but also included in the percentage cover of total grasses category.

See identification guide for commonly sown winter bird food species.

Boundary tab – record the type of boundary feature the winter bird food option runs along (list on recording form).

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = evidence not being met); leave blank if no evidence either way.

Record aspect and presence of overhanging trees as for nectar flower mix above.

Record evidence of poaching or compaction.

Record whether there is evidence of cutting (recent / not recent / none), not recent = cut this year but substantial regrowth.

5) Autumn sown bumblebird

Recording form name in database	**Options**
AutumnBumblebirdMix	AB16

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground. Some potential sown species will autofill in the species list along with the grass categories; this is a prompt to look out for these and not an exclusive species list. Some of the sown species are crop species and graminoids; for these percentage cover should be recorded to species level, but also included in the percentage cover of total grasses category.

See identification guide for commonly sown species.

Boundary tab - Record the type of boundary feature the autumn sown bumblebird option runs along (list on recording form).

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = evidence not being met); leave blank if no evidence either way.

Record aspect and presence of overhanging trees as for nectar flower mix above.

Record evidence of poaching or compaction.

Record whether there is evidence of cutting (recent / not recent / none), not recent = cut this year but substantial regrowth.

6) Cultivated areas arable

Recording form name in database	**Options**
CultivatedAreas_Arable	AB11 EF11 HF9 HF10 HF14 HF20

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground, as for grass buffer strips above.

Adjacent habitat tab - Record the type of boundary feature (adjacent habitat) the buffer strip runs along, if one is present.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = evidence not being met); leave blank if no evidence either way.

Record aspect and presence of overhanging trees as for nectar flower mix above.

7) Buffers around ponds and ditches on arable land

Recording form name in database	**Options**
BufferPonds	WT2

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground, as for grass buffer strips above.

As for ditch management options above, place quadrats on the permanent vegetation associated with the pond or ditch. If scrub is present, record the five quadrats on herbaceous vegetation patches.

Grass buffer strip tab - Record sward height at 20 positions across the option as described in general guidance above.

Record the type of boundary feature (adjacent habitat) the buffer strip runs along, if one is present.

Record whether there is evidence of cutting (recent / not recent / none), not recent = cut this year but substantial regrowth.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record whether scrub is present on the south side of the strip, and if yes, what proportion of the total length southern side is covered in scrub?

Record the number of scrub patches and number of herbaceous vegetation patches across the whole option if possible.

Scrub tab – record the % cover of scrub and % cover of herbaceous vegetation. If whole option area is too big to view, subsample five 20m long areas selected at random. Enter patch numbers 1-5 in patch no. column. If recording whole option enter under patch 1.

Scrub cover tab - Record the list of woody species present in scrub with estimated percentages. Note this is separate to the quadrat data tab as quadrats were recorded in herbaceous patches. If the whole option area is too big to view, subsample five 20 m long areas selected at random to assess scrub cover.

8) Woodland edges on arable land

Recording form name in database	**Options**
WoodlandEdges	WD3 EC4

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground, as for grass buffer strips above. If scrub is present, record the five quadrats on herbaceous vegetation patches.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record the number of scrub patches and number of herbaceous vegetation patches across the whole option if possible.

Scrub tab – record the % cover of scrub and % cover of herbaceous vegetation. If whole option area is too big to view, subsample five 20m long areas selected at random. Enter patch numbers 1-5 in patch no. column. If recording whole option enter under patch 1.

Scrub cover tab - Record the list of woody species present in scrub with estimated percentages. Note this is separate to the quadrat data tab as quadrats were recorded in herbaceous patches. If whole option area is too big to view, subsample five 20 m long areas selected at random.

9) Beetle banks

Recording form name in database	**Options**
BeetleBanks	AB3 EF7 HF7

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground, as for grass buffer strips above.

Ridge / sward height tab - Record the height and width of the ridge in cm above the height of the rest of the field.

Record sward height at 20 positions across the option as described in general guidance above.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record the width of working gap at each end of the beetle bank (in metres).

Record whether there is evidence of cutting (recent / not recent / none), not recent = cut this year but substantial regrowth.

10) Small areas out of management

Recording form name in database	**Options**
SmAreasOutOfManagement	GS1 EF1 HF1

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground, as for grass buffer strips above.

Sward heights tab – record sward height at 20 positions across the option as described in general guidance above.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

11) Hedgerows

Recording form name in database	Options
Hedgerows	BE3 BN5 EB1 EB2 EB3 EB8 EB9 EB10 HB11 HB12 OB1 OB2 OB3

Resurveying lowland square hedgerow options that were surveyed in 2017

Using the lowland square implementation map, revisit all hedgerow options surveyed in 2017. In addition to the floral assessment (D above), enter a record on the hedgerow form, but only record answers to the following two questions:
(1) Whether there is evidence of recent hedgerow management (cutting, coppicing or hedge-laying)
(2) For hedges that have been cut, the timing of the most recent cut (1, 2, 3 or > 3 years growth since latest cut).

Ignore the rest of the hedgerow recording form data entry fields for lowland hedgerow options.

Surveying upland square hedgerow options for the first time

Do a full survey for each hedgerow option, filling in all the data entry fields in the hedgerow form. Remember to also do the floral assessment.

Quadrat tab – Place the five quadrats to assess the permanent ground flora associated with the hedgerow, as close to the hedgerow edge as possible.

Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground, as for grass buffer strips above.

Also record the total cover of all woody species (together as a category) that are suckering into the ground flora or present as seedlings.

Hedge Dimensions tab – at 5 equally spaced positions along the hedge length (avoiding the end 5m of the hedge) measure the height and width of the hedge using the marked canes provided. If needbe the two canes may need to be taped together for taller hedges. Width is assessed to the centre of the hedge (i.e. half total hedge width); both width and height should be entered in meters. Enter 1-5 in the Measurement column for the five replicates.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record whether there is evidence of recent hedgerow management (cutting, coppicing or hedge-laying), and for hedges that have been cut, the timing of the most recent cut (1, 2, 3 or > 3 years growth since latest cut).

Estimate the % cover of non-native woody species along the side of the hedgerow facing you.

Estimate the % of gaps along the hedgerow length.
Count the number of hedgerow trees and record these in two categories: <7cm dbh and > 7cm dbh.

Count the number of native woody species in two 30m lengths of the hedgerow, evenly spaced but avoiding the end 5m of hedge. Table A1.8 below gives a list of native woody species.

12) Successional areas

Recording form name in database	**Options**
SuccessionalAreas	WD7 HC15 HC16

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground, as for grass buffer strips above. If scrub is present, record the five quadrats on herbaceous vegetation patches.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record the number of discrete scrub patches and number of herbaceous vegetation patches across the whole option if possible.

Scrub tab – record the % cover of scrub and % cover of herbaceous vegetation. If whole option area is too big to view, subsample five 20m long areas selected at random. Enter patch numbers 1-5 in patch no. column. If recording whole option enter under patch 1.

Scrub cover tab - Record the list of woody species present in scrub with estimated percentages. Note this is separate to the quadrat data tab as quadrats were recorded in herbaceous patches. If whole option area is too big to view, subsample five 20 m long areas selected at random. If recording whole option enter under patch 1.

13) Sown legume fallow

Recording form name in database	**Options**
SownLegumeFallow	AB15

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground. Some potential sown species will autofill in the species list along with the grass categories; this is a prompt to look out for these and not an exclusive species list. Some of the sown species are grasses; for these percentage cover should be recorded to species level, but also included in the percentage cover of total grasses category.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record any evidence of cutting, either this year or last year

Black grass tab – approximately count the number of blackgrass seed heads in each of ten 0.5 × 0.5 meter quadrats. If the counts are large do not spend too long getting a very accurate count – count approximately to nearest 20 or 50 seedheads. In the quadrat number column, enter 1 - 10 for the 10 quadrats.

14) Skylark plots

Recording form name in database	Options
SkylarkPlots	AB4 HF8 EF8

Quadrat tab - Within each of five quadrats, record the percentage cover of each forb to species level, grasses to categories (tussocky grass, fine grass, total grass cover), and cover of dead vegetation / litter and bare ground.

Plots tab – Record the plot width and length in metres, the distance in metres from the nearest tramline and the total vegetation cover.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record the approximate percentage of field boundary made up of woodland (to nearest 10%)

Estimate the % of plots within the field that are closer than 50m from the nearest boundary

15) Lapwing and stone curlew plots

Recording form name in database	Options
Lapwing_StoneCurlew	AB5 EF13 HF13 OHF13

Quadrat tab - Within each of five quadrats, record the percentage cover of each higher plant species to species level and cover of dead vegetation / litter and bare ground.

Note grass cover is recorded to species and not in categories for this form.

Prescription tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

Record the approximate percentage of field boundary made up of woodland (to nearest 10%)

If possible, record the minimum distance from woods, in-field and hedgerow trees, buildings, overhead power-lines, main roads and public rights of way

Estimate the slope of the plot

Record whether any of the adjacent fields grassland? If so, does this appear to be extensively or intensively managed?

16) Species rich grassland, wet grassland, grassland for target features options

Recording form name in database	**Options**
Grassland	GS6 GS7 GS8 GS9 GS10 GS11 GS12 GS13 GS14 HK6 HK7 HK8 HK10 HK12 HK9 HK15 HK16

Quadrat tab - Within each of five quadrats, record the percentage cover of each higher plant species to species level and cover of dead vegetation / litter and bare ground.

Note grass cover is recorded to species and not in categories for this form.

Sward height tab - Record sward height at 20 positions across the option as described in general guidance above.

Criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

17) Permanent grassland with low or very low inputs

Recording form name in database	Options
PermGrassland_LowInput	GS2 EK2 EK3 EL2 EL3 EL4 GS5 HL2 HL4 OK2 OK3 OL2 OL3 UL20 UL23

Quadrat tab - Within each of five quadrats, record the percentage cover of each higher plant species to species level and cover of dead vegetation / litter and bare ground.

Note grass cover is recorded to species and not in categories for this form.

Sward height tab - Record sward height at 20 positions across the option as described in general guidance above.

Prescription criteria tab - For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

18) Upland enclosed rough grazing < 15ha

Recording form name in database	**Options**
UplandEnclosedRoughGrazing	UP1 EL5

Quadrat tab - Within each of five quadrats $1m^2$ quadrats, record the percentage cover of each higher plant species to species level and cover of dead vegetation / litter and bare ground.

Note grass cover is recorded to species and not in categories for this form.

Sward height tab - Record sward height at 20 positions across the option as described in general guidance above.

Rushes/prescription criteria tab – across the whole parcel record the presence of rushes in one of these categories: small discrete patches / a few large patches / 1-2 large patches / most of parcel / all of parcel.

For each eligibility and prescription criteria, record whether there is evidence they are not being met (yes = not being met); leave blank if no evidence either way.

19) Upland moorland and rough grazing options – often unenclosed

Recording form name in database	**Options**
UplandMoorlandRoughGrazing	UP2 UP3 HL8 HL9 HL10 EL6

As these options are often on unenclosed parcels (see below if enclosed), record a separate implementation assessment for each different broad habitat you have mapped within each parcel for each of these options. Record which of the broad habitats you are assessing within the *Grazing unit/Prescription criteria* tab.

If more than one of the options above are present within one parcel, record the data under one option code, but add the other codes in the notes tab of the recording form.

These are the only options where bigger quadrats are used. For each assessment, record ten 2 × 2 m^2 quadrats (within each broad habitat mapped within each parcel).

Quadrat tab - Within each of ten 2 × 2 quadrats m^2 quadrats, record the percentage cover of each higher plant species to species level and cover of dead vegetation / litter and bare ground.

Note grass cover is recorded to species and not in categories for this form.

Sward height tab - Record sward height at 20 positions across the option as described in general guidance above.

Grazing unit/Prescription criteria tab – Assessments for this tab apply to the whole parcel and broad habitat you are assessing within your survey square. Make these assessments approximately based on the W route you have walked for your quadrats – do not try to cover the whole area.

Record which of the broad habitats you have recorded your data in.

Approximately estimate the cover of trees, scrub, bracken and invasive/undesirable plants.

If Calluna is present, record any signs of management. Choose from burning / cutting / grazing / none

If Calluna is present, record the dominant growth stage within the parcel and broad habitat. Choose from: pioneer / building / mature / degenerate

Figure A1.10 may help to define the growth stage.

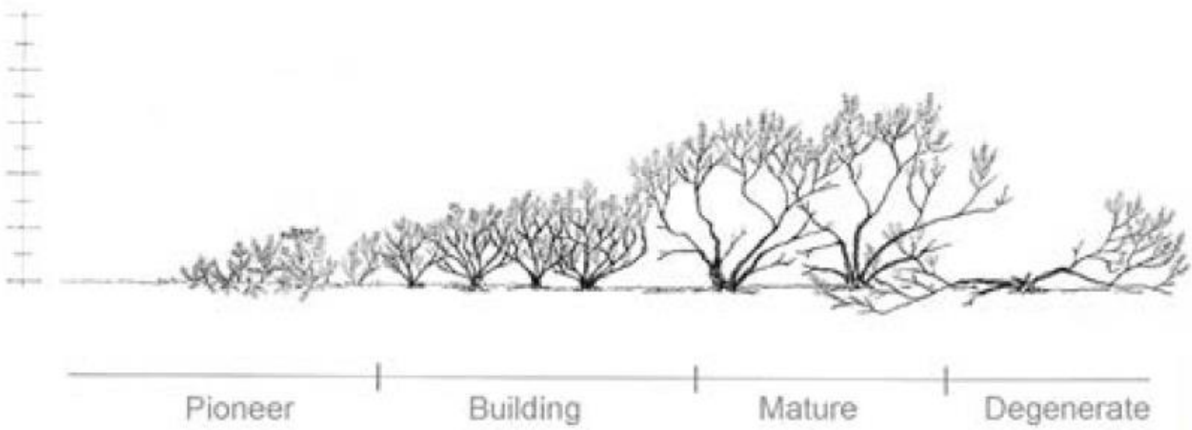


Figure A1.10 Growth stages of Calluna. Reproduced from CS Baseline Surveyor Handbook (FERA Science Ltd).

For each criteria, record whether there is evidence of any of these types of management activities; leave blank if no evidence either way.

If these options are on a smaller enclosed parcel (e.g. HL8, HL9), use the same recording form (UplandMoorlandRoughGrazing) in the database but record only 5 quadrats if you estimate the option polygon size <15ha. The database will allow you to save the record with data for only 5 quadrats. Ensure you also fill in the other tabs. Please write “Enclosed” in the notes.

Table A1.8 Woody species and native / non-native category for hedgerow option implementation assessment.

Species	Woodland				Hedges		
	Native	Honorary Native	Non native	Invasives/ Must not be planted	Native	Non native	Invasives
Abies alba			y			y	
Abies amabilis			y			y	
Abies fraseri			y			y	
Abies grandis			y			y	
Abies nordmanniana			y			y	
Abies procera			y			y	
Abies spp.			y			y	
Acer campestre	y				y		
Acer macrophyllum			y			y	
Acer platanoides			y			y	
Acer pseudoplatanus		y					y
Acer saccharinum			y			y	
Aesculus hippocastanum			y			y	
Ailanthus altiissima			y				y
Alnus cordata			y			y	
Alnus glutinosa	y				y		
Alnus incana			y			y	
Alnus rubra			y			y	
Alnus viridis			y			y	
Arbutus unedo			y			y	
Aucuba japonica				y			y
Betula pendula	y				y		
Betula pubescens	y				y		
Buxus sempervirens	y				y		
Carpinus betulus	y				y		
Castanea sativa		y				y	
Cedrus atlantica			y			y	
Cedrus libani			y			y	
Cedrus spp.			y			y	
Chamaecyparis spp.			y			y	
Chamaecyparis lawsoniana			y			y	
Cornus mas			y			y	
Cornus sanguinea	y				y		
Cornus sericea			y				y
Corylus avellana	y				y		
Cotoneaster cambricus						y	
Cotoneaster horizontalis			y				y
Cotoneaster integrifolius			y				y
Cotoneaster microphyllos			y				y
Cotoneaster simonsii			y				y
Crataegus laevigata	y				y		
Crataegus monogyna	y				y		
Cryptomeria japonica			y			y	
Cytisus scoparius	y				y		

Species	Woodland				Hedges		
	Native	**Honorary Native**	**Non native**	**Invasives/ Must not be planted**	**Native**	**Non native**	**Invasives**
Cuprocyparis leylandii – (Syn. × Cupressocyparis leylandii)			y			y	
Daphne mezereum					y		
Eucalyptus gunnii			y			y	
Eucalyptus nitens			y			y	
Eucalyptus pauciflora			y			y	
Euonymus europaeus	y				y		
Euonymus japonicus			y			y	
Fagus sylvatica	y				y		
Frangula alnus	y				y		
Fraxinus excelsior	y			y	y		
Fuschia magellanica			y			y	
Gaultheria shallon				y			y
Hippophae rhamnoides				y			y
Ilex aquifolium	y				y		
Juniperus communis	y				y		
Juglans nigra			y			y	
Juglans regia			y			y	
Laburnum anagyroides			y			y	
Laurus nobilis				y			y
Larix × marschlinsii (Syn. L. × eurolepis)			y			y	
Larix decidua			y			y	
Larix kaempferi			y			y	
Larix spp.			y			y	
Ligustrum ovalifolium			y			y	
Ligustrum vulgare	y				y		
Lycium barbarum			y			y	
Mahonia aquifolium			y			y	
Malus sylvestris	y				y		
Malus domestica			y			y	
Mespilus germanica			y			y	
Nothofagus alpina (Syn. N. procera and N. nervosa)			y			y	
Nothofagus obliqua			y			y	
Nothofagus pumilio			y			y	
Picea abies			y			y	
Picea omorika			y			y	
Picea orientalis			y			y	
Picea pungens			y			y	
Picea sitchensis			y			y	
Picea spp.			y			y	
Pinus contorta			y				y
Pinus monticola			y			y	
Pinus nigra			y				y
Pinus nigra subsp. nigra			y				y

Species	Woodland				Hedges		
	Native	Honorary Native	Non native	Invasives/ Must not be planted	Native	Non native	Invasives
Pinus nigra ssp. laricio (Syn. P. nigra var. maritima)			y				y
Pinus peuce			y			y	
Pinus pinaster			y				y
Pinus radiata			y			y	
Pinus sp			y			y	
Pinus strobus			y			y	
Pinus sylvestris			y			y	
Pittosporum crassifolium			y			y	
Pittosporum tenuifolium			y			y	
Platanus × hispanica			y			y	
Populus × canadensis			y			y	
Populus × canescens	y				y		
Populus × generosa			y			y	
Populus alba	y				y		
Populus nigra			y			y	
Populus nigra ssp betulifolia	y				y		
Populus tremula	y				y		
Populus trichocarpa			y			y	
Prunus avium	y				y		
Prunus cerasifera			y			y	
Prunus cerasus			y			y	
Prunus domestica			y				y
Prunus laurocerasus				y			y
Prunus lusitanica			y				y
Prunus padus	y				y		
Prunus serotina			y				y
Prunus spinosa	y				y		
Pyrus cordata	y				y		
Pyrus pyraster	y				y		
Pseudotsuga menziesii			y			y	
Quercus cerris		y					y
Quercus ilex		y					y
Quercus petraea	y				y		
Quercus robur	y				y		
Quercus rubra			y				y
Rhamnus cathartica	y				y		
Rhododendron luteum				y			y
Rhododendron ponticum				y			y
Rhododendron spp.				y			y
Ribes alpinum	y				y		
Ribes nigrum			y			y	
Ribes rubrum	y				y		
Ribes spicatum	y				y		
Ribes uva-crispa			y			y	
Robinia pseudoacacia			y				y

Species	Woodland				Hedges		
	Native	Honorary Native	Non native	Invasives/ Must not be planted	Native	Non native	Invasives
Rosa agrestis	y				y		
Rosa arvensis	y				y		
Rosa caesia	y				y		
Rosa canina agg.	y				y		
Rosa Hollandica			y				y
Rosa micrantha	y				y		
Rosa mollis agg.	y				y		
Rosa obtusifolia	y				y		
Rosa rubiginosa	y				y		
Rosa rugosa			y				y
Rosa sherardii	y				y		
Rosa stylosa	y				y		
Rosa tomentosa	y				y		
Rubus idaeus	y				y		
Ruscus aculeatus	y				y		
Salix alba			y			y	
Salix aurita	y				y		
Salix caprea	y				y		
Salix cinerea	y				y		
Salix fragilis			y			y	
Salix myrsinifolia	y				y		
Salix pentandra	y				y		
Salix phylicifolia	y				y		
Salix purpurea	y				y		
Salix triandra			y			y	
Salix viminalis	y				y		
Sambucus nigra	y				y		
Sambucus racemosa			y			y	
Sequoia sempervirens			y			y	
Sequoiadendron giganteum			y			y	
Sorbus aria agg	y				y		
Sorbus aucuparia	y				y		
Sorbus domestica	y				y		
Sorbus intermedia agg	y				y		
Sorbus latifolia agg	y				y		
Sorbus torminalis	y				y		
Sorbus x thuringiaca	y				y		
Symphoricarpos alba				y			y
Syringa vulgaris			y			y	
Taxus baccata	y				y		
Tamarix gallica			y			y	
Thuja plicata			y			y	
Tilia cordata	y				y		
Tilia platyphyllos	y				y		
Tilia x europea	y				y		
Tsuga heterophylla			y			y	

Species	Woodland				Hedges		
	Native	Honorary Native	Non native	Invasives/ Must not be planted	Native	Non native	Invasives
Tsuga spp.			y			y	
Ulex europaeus				y	y		
Ulex gallii				y	y		
Ulex minor				y	y		
Ulmus glabra	y				y		
Ulmus x hollandica	y				y		
Ulmus minor	y				y		
Ulmus plotii	y				y		
Ulmus procera	y				y		
Ulmus x vegeta	y				y		
Viburnum lantana	y				y		
Viburnum opulus	y				y		

Note: *Lonicera periclymenum, Clematis vitalba, Hedera helix, Rubus fruticosus* agg. are all woody species but do not count towards no. of woody hedgerow species.

A2 Bat monitoring pilot 2017

A2.1 Background

Full spectrum bat detector technology, where detectors are left out to trigger automatically all night and to capture bat calls at their original frequency, retains more detail of the call than other detector types. When used in conjunction with call identification software and validation (Newson et al., 2015), this approach offers great potential for transforming bat monitoring in the UK. Acoustic identification of some bat species, in particular bats in the genus *Myotis* is challenging, but improving rapidly. The majority of species are identified reliably in the vast majority of recordings and, by retaining recordings, there is the potential to re-analyse them as processes improve. Using passive detectors in this way, there is the potential to provide representative acoustic monitoring of bat species occurrence and activity, either or both of which may provide a proxy for abundance. This approach can generate a large volume of recordings per night as a measure of relative abundance, but the number of recordings can be highly variable depending on nightly weather conditions, local habitat and use of particular features in the landscape, for example proximity to a roost. To address sampling noise, objectivity, replication and habitat representation is required.

The concept of this pilot was to explore the potential of passive detector data for quantifying the influence of AES option presence on bat occurrence and activity, by considering distance to habitats known to influence bats as a proxy for AES management effects, whilst controlling for habitat in the wider landscape. Specifically, we considered distance to nearest woody linear feature, distance to nearest woodland and distance to nearest water, which the literature suggests are important for a number of UK bat species. Detection of these local habitat effects would suggest that the field approach and intensity of sampling is sufficiently sensitive to real variations in bat occurrence or activity to make the detection of local AES management effects realistic.

Importantly, the 3km × 3km spatial resolution of the overall survey design was broadly consistent with the average 'Core Sustenance Zones (CSZ)' for different UK bat species (Bat Conservation Trust, 2020; Table A3.11). The CSZ varies between 10 bat species from a radius of 1km for Whiskered Bat *Myotis mystacinus* to 4 km for Noctule *Nyctalus noctule*, with Barbastelle *Barbastelle barbastellus* being considered wider ranging at 6km (Table A2.1). The CSZ is defined as the area surrounding a communal bat roost within which habitat availability and quality may influence the resilience and conservation status of that colony, so the survey was viable in terms of the scale over which to test for bats responding to AES habitat interventions. Thus, given sufficient analytical power, the working premise was that bats will respond positively to the presence of an AES resource or gradient that increases prey abundance or availability at those scales, relative to background levels.

Secondly, the survey protocol was considerably more intensive than was expected to be needed, in order to allow sub-sampling from the data to inform about necessary levels of survey effort to detect effects. Specifically, two elements of the level of survey effort were considered: variation in the number of sampling occasions (blocks of recording nights) within a season and the number of continuous nights of bat recording per session.

A2.2 Methods

Fieldwork involved the simultaneous deployment of two bat detectors (Wildlife Acoustics SM4Bat-FS detectors) within each survey 1-km square in the Fens and the South Suffolk and North Essex Clayland, which were left out to trigger automatically and thus to record bats over six consecutive days per session (defined as a sampling occasion). The multi-night deployment per location was implemented in order to average out expected variation in bat activity due to weather, and also to increase the chance of detecting species that are present in the survey area at lower density, or that have a low detection probability. Depending on the timing of the confirmation of survey access and the logistics of combining bat and bird sampling, up to four sampling sessions were conducted in each square between May and the end of September 2017.

A2.2.1 Semi-automated acoustic identification of bats

Passive real-time detectors are triggered when they detect sound within a certain frequency range. Monitoring on this scale can generate a very large volume of recordings, efficient processing of which is greatly aided by a semi-automated approach for assigning recordings to species. In this study we made use of an acoustic classifier TADARIDA (a Toolbox for Animal Detection in Acoustic Recordings Integrating Discriminant Analysis; Bas 2016; Bas et al., 2017). All recordings from the bat survey were passed through the TADARIDA random forest classifier (Step 1). This entailed extraction of 150 measures of call characteristics from each recording (Bas et al., 2017), and a comparison of these against measurements taken from an extensive reference library of manually identified ultrasound recordings.

The classifier allows up to four different "identities" to be assigned to a single recording, according to probability distributions between detected and classified sound events. From these, species identities are assigned by the classifier, along with an estimated probability of correct classification (as compared with the underlying training database) on a scale of 0–1. For common Pipistrellus pipistrellus and soprano pipistrelle Pipistrellus pygmaeus, which accounted for >95% of all bat recordings made during the survey, the call shape (similar to a hockey-stick) and frequencies of common and soprano pipistrelle are sufficiently characteristic to allow reliable classification of these species by the classifier. For these species, TADARIDA identifications for which the estimated probability of correct classification was high (≥ 0.8), were taken as being accurate (NB. in the analysis for the monitoring (2018, 2019, 2021) we used a >/=0.5 threshold but manually checked all records, apart from for Common and Soprano Pipistrelles for which 1000 records were checked, as described in Section A3.4 below).

Manual checking (Step 2) of spectrograms using software SonoBat (http://sonobat.com) was used as an independent check of the original species identities assigned by the TADARIDA classifier. Using the output from Step 1, manual checks were carried out on a random sample of 500 recordings each of common and soprano pipistrelle, to verify that classifier identification of these species was accurate. For the other species, we inspected all recordings with SonoBat regardless of the associated probability of correct classification. Species identities were checked (and re-classified if necessary) based on call parameters defined in Russ (2012) and Barataud (2015).

Once species identities had been checked by looking at individual recordings in isolation, calls assigned to species whose calls had the most potential to be confused with those of other species (e.g. bats in the genus Myotis and Nyctalus) were re-examined in SonoBat, comparing them to other recordings potentially of the same bat made from the same location on the same night at neighbouring points in time (Step 3). All subsequent analyses use final identities upon completion of the above inspection and (where necessary) correction steps.

A2.2.2 Data analyses

Bat data

All data analysis was conducted in R (R Core Team 2015). For each survey point, the total number of passes for each bat species recorded during the night was determined (bat activity as a measure of relative abundance). Additionally, these data were simplified to presence/absence per night (bat occurrence).

Because the foraging radii of different species of bats in the UK is very different, it is likely that different species will respond to habitat in the wider landscape at different spatial scales (Hale et al., 2012; Lintott et al., 2015ab). To account for this, we calculated the area of available habitat around each survey point for each species, where the radius around each survey point varied for each species according to a published mean-maximum foraging distance for each species (Core Sustenance Zone, Bat Conservation Trust 2016, Table A3.11).

Local and landscape scale habitat

We initially considered including seven landscape scale variables, including four derived from LCM2015 data (the area of broadleaved woodland, coniferous woodland, freshwater and built-up habitat) and three from UKCEH woody linear feature data (area of hedgerow, tree canopy and wooded strip). However, several variables were highly correlated with one another (Pearson Product Moment Correlation Coefficient, $r > 0.8$). Specifically area of hedgerow, area of tree canopy and area of wooded strip were highly correlated with one another at all foraging radii (Table A2.2). In addition, area of broad-leaved woodland, area of hedgerow and area of wooded strip were highly correlated with one another at 4 and 6-km. For this reason we reduced the number of landscape variables to four (area of coniferous woodland, freshwater, built-up habitat and hedgerow).

As surrogates for the local scale AES option, we considered three local habitat features which were not correlated with the landscape scale variables. This included distance to nearest woodland, distance to nearest freshwater and distance to nearest woody linear feature.

Modelling approach

Of eleven bat species recorded, Nathusius' Pipistrelle and Whiskered / Brandt's bat were only recorded from three 1-km squares, and so were excluded from the following analyses (Table A2.1). For all other species and analyses here, occurrence was modelled using a binomial Generalized Linear Model (GLM) using the lme4 package (Bates et al., 2015). Before analysis, the bat data were aggregated across multiple visits to the same sampling point for each species to calculate the number of events and trials and mean activity (average number of recordings). The four landscape scale habitat variables were included in all models as control variables, and each local scale variable was included individually in separate models. Environmental predictors were centred and standardised before implementing the model. Bat activity was modelled with a quasi-Poisson GLM, which we chose in preferred to Poisson because it was better able to account for some over-dispersion in the data, and included the same covariates. Habitat variables were considered significant if $p < 0.05$. These analyses were initially run on the full dataset.

Sub-sampling

In order to investigate the implications of variation in sampling effort, we randomly sub-sampled nights within sessions or whole sessions from the full dataset (with 1,000 replicates) without replacement. The stability or consistency of model coefficients across replicates then provided a guide to the reliability of inference from different sampling structures. The specific variations investigated were:

1. The number of nights of recording (1-6) within sampling occasions
2. The number of sampling occasions (1-4)

Because increasing the number of sampling occasions may increase variation in the data if bat distribution and activity varies within the season, we also ran analyses on data for May-July and for August to September (post-breeding dispersal) separately, to see whether there was evidence for differences in the influence of replication on study power to detect habitat associations when repeat sampling should not cover periods with additional patterns of variation in real activity or occurrence.

A2.3 Results

A2.3.1 Survey coverage

18 different 1-km squares were surveyed for bats during the project, nine in each of the two NCAs considered. This sample comprised 750 complete nights of recording at 145 different recording locations. 2,155,547 recordings were collected which, following analyses and validation, were found to include 156,786 bat recordings (Table A2.1). The remaining recordings mainly comprised bush-crickets, and recordings of other mammals, mainly small mammals, and birds. Manual checking of 500 randomly selected recordings each of common and soprano pipistrelle suggested that less than 1% of recordings were incorrectly assigned (in most of these cases to the other species) which we deemed an acceptable error rate for these highly abundant and geographically widespread species.

A2.3.2 Full dataset: importance of local habitat on bat occurrence

Of the nine species for which there were sufficient data to look at the importance of local habitat, common and soprano pipistrelle were the most widespread, being recorded from 98% and 81% of survey points respectively (Table A2.1). This was followed by Daubenton's Bat, Noctule, and Brown Long-eared Bat, which were all recorded from over 50% of points, with all other bat species being recorded at less than 50% of surveyed locations (28-48%). Using the full dataset, we found a significant negative association between bat occurrence and distance to the nearest hedgerow (i.e. the species was significantly more likely to recorded closer to a hedgerow) for five of nine species of bat (Table A2.3). As exceptions, serotine and Natterer's Bat were significantly less likely to be recorded closer to a hedgerow. Three species of bat, noctule, soprano pipistrelle and common pipistrelle, were significantly more likely to be recorded closer to water, whilst serotine and Natterer's Bat were significantly less likely to be recorded closer to water. Lastly for distance to nearest woodland, five of nine species of bat were significantly more likely to be recorded closer to woodland, whilst three species, Serotine, Natterer's Bat and Leisler's bat were significantly less likely to be recorded closer to woodland.

A2.3.3 Full dataset: importance of local habitat on bat activity

Fewer significant associations between bat activity and distance from local habitat were found. This included significantly higher activity of Barbastelle and Serotine closer to hedgerows, and significantly lower Noctule and Soprano Pipistrelle closer to hedgerows. Activity of Noctule and Soprano Pipistrelle was significant higher closer to water, and for Noctule, significantly lower closer to woodland.

Sub- sampling: influence of number of nights of recording within sampling occasion
The number of nights of continuous recording at survey points within sampling occasions varied between 3 and 8, with a mean of 6.6. In the following analysis, we focus on the significant local habitat associations identified with the whole dataset, and randomly select 1 to 6 recording nights within sampling occasions (or up to the maximum nights surveyed if it were less than this). Models were run on 1,000 random subsamples, and box plots were produced to illustrate the variation in model coefficients. In Figure A2.1, we show how variations in model coefficients for significant associations with bat occurrence, based on the full dataset, decrease with an increasing number of nights of recording at the same location within sampling occasion. Figure A2.2 repeats the same analysis for bat activity.

For occurrence and activity, the likelihood of detecting a significant habitat association increases as the number of nights of recording effort increases within sampling occasion. However, the benefit of increasing the number of number of nights of recording is not linear and generally appears greatest as the number of nights of recording increases from one to two, with little added benefit from increases above four nights. As an additional approach to visualizing the variation, the standard error of the mean of each distribution (with respect to the number of nights) was also plotted, considering all relationships instead of the significant ones alone (Figures A2.3 and A2.4). These confirm that improvements in power become only very small with more than four nights of sampling.

A2.3.4 Sub-sampling: varying the number of sampling occasions

In Figure A2.5, we show how variation in model coefficients for bat occurrence and so power to detect a habitat association change with the number of sampling occasions (blocks of recording). In Figure 3.7, we repeat the analyses for bat activity. Figures A2.5 and A2.6 demonstrate that increasing the number of sampling occasions will increase the power to detect a habitat association. For almost all species-habitat associations, there was a clear benefit, from sampling in two or more sessions. This was especially clear for activity models (Figure A2.6). Representing the variation in terms of standard errors of the distributions considered re-iterated the pattern for the principal increase in power to come from moving from one to two sampling occasions, with smaller increases often occurring between three and four sessions, but there being no clear patterns of change between two and three sessions (Figures A2.7 and A2.8).

A potential reason for this pattern may be that the habitat associations or strength of the habitat associations for a species change seasonally. If this were the case, we would expect that the differences would be most noticeable between breeding (June-July) and post-breeding (August-September), and that randomly sampling two or three sessions, as opposed to one or two, might either increase the sampling effort for a consistent, underlying pattern of real bat occurrence and activity, or broaden sampling to cover periods with different underlying patterns, and hence consider fundamentally more variable data. Thus, moving from two to three sessions will often mean sampling a second period with a different pattern of real bat activity or occurrence and, hence, not increase power. To examine this, we repeated the analysis in Tables A2.3 and A2.4, but instead of using the full dataset, we split the data into two, data from June-July and for August-September (Tables A2.5 and A2.6). There were some noticeable differences in model coefficients for some species between the early and late part of the season. There was a stronger association with distance to hedgerow and woodland later in the season (post-breeding) for Daubenton's bat and common pipistrelle occurrence, and a much stronger positive association with distance to water later in the season for soprano pipistrelle (Table A2.5). Leisler's bat was also only associated with woodland late in the season (Table A2.5). Conversely, significant results for natterer's bat were only found early in the season and, while patterns for noctule and serotine bat were consistent throughout the season, significant results for brown long-eared and barbastelle bat were found only when early and late season data were combined (cf. Tables A2.3 and A2.5), indicating that coverage of the whole season was valuable. As elsewhere in the study, there were fewer significant results with respect to bat activity, but four of seven patterns were found only in the early season and two only in the late season (Table A2.6).

Overall, these results indicate that multiple sampling sessions are required (a minimum of two per year) and that they should be divided between the early and late seasons. It would seem advisable to consider four sampling sessions, where possible. It should also be noted that multiple sampling sessions are useful for increasing the potential for detecting more species and producing a more complete picture of local bat communities. This aspect of power was not addressed here, because the focus was on the detection of habitat relationships, rather than on characterizing entire communities.

A2.4 Conclusions

Passive acoustic bat recording has encouraging power, shown by significant results for most species, to detect the effects of local land-use / land management on bat occurrence per night (probability of detection), but is less useful with respect to bat activity (as currently summarized). Note that presence per night is a more information-rich parameter than simple presence, because of the repeat sampling over successive nights and multiple sampling occasions in the season. It can be considered to form an index of abundance, in the same way as multiple sampling sessions with other forms of passive sampling (e.g. pitfall traps or pan traps) would do: repeated detections are likely to reflect the presence of more individuals. Note also that the activity data provide a ready check as to whether differences might reflect variation in individual activity alone.

This indicates that this approach for bat monitoring can fruitfully be repeated and rolled out to further NCAs from 2018 onwards, with high confidence that effects of AES management would be detectable.

Simulations were carried out to look at the power to inform the most cost-effective sampling regime. The first of these looked at varying the length of individual sampling occasions (up to six consecutive nights). This found that 4 consecutive nights of recording should be conducted in each sampling session at each survey point, with more nights being valuable if feasible. Multiple nights of recording per session are likely to smooth over stochastic and weather-related variation, while also being easy to implement logistically (once a detector is on site, it is much easier to leave in it situ for another night, battery life permitting, than to move it).

A second set of simulations looked at variation in the number of discrete sampling occasions to carry out per season (up to a maximum of four sampling occasions). Having multiple sampling occasions is likely to be important for taking seasonal changes in distribution and activity patterns into account, as well as effectively smoothing over further stochastic variation in the data recorded within individual sessions. The pilot demonstrates that there are changes in the detectability of habitat associations according to time of year for some species at least. Varying the number of sampling occasions, the results suggest that a minimum of two sampling occasions are required, one each in the early and late summer period, with repeat sessions in each of these two periods if possible. The timing of sampling occasions should then use windows of time that are likely to reflect bat biology.

Overall, the results indicate that the bat sampling approach is fit for purpose and suitable for roll-out to further NCAs, with lower sampling effort than was employed per NCA in 2017.

A2.5 Tables and figures for bat pilot study (2017) results

Table A2.1 Bat species detected through the fieldwork, number of recordings of each species following validation, summary of the scale of recording and mean-maximum foraging distance (from BCT 2016, referred to as Core Sustenance Zone; see Table A).

Species	No. of recordings following validation	No. of different 1-km squares (% of total)	No. of different survey points (% of total)	Core sustenance zone, km
Daubenton's bat	3,656	22 (95.7)	97 (66.9)	2 km
Whiskered / Brandt's bat	17	3 (13)	3 (2.1)	-
Natterer's bat	670	19 (82.6)	70 (48.3)	4 km
Noctule	5,446	18 (78.3)	86 (59.3)	4 km
Leisler's bat	927	17 (73.9)	60 (41.4)	3 km
Serotine	724	12 (52.2)	41 (28.3)	4 km
Common pipistrelle	113.540	23 (100)	142 (97.9)	2 km
Soprano pipistrelle	21,309	21 (91.3)	118 (81.4)	3 km
Nathusius' pipistrelle	5	3 (13)	4 (2.8)	-
Brown long-eared bat	900	17 (73.9)	75 (51.7)	3 km
Barbastelle	3,691	20 (87.0)	55 (37.9)	6 km
Myotis species	281	20 (87)	66 (45.5)	-
Pipistrellus species	5,041	23 (100)	129 (89)	-
Nyctalus species	579	19 (82.6)	65 (44.8)	-

Table A2.2 Correlation (Pearson Product Moment Correlation Coefficient) between habitat variables at different radii (Tables A2.2a-b below) out from the sampling points. We highlight correlations where r > 0.8**.** Blwood = broad-leaved woodland, Conifwood = coniferous woodland

(a) 2-km radius (core sustenance zone for Daubenton's bat and common pipistrelle)

	Landscape scale (area)							**Local scale (distance to nearest)**		
	Blwood	**Conifwood**	**Freshwater**	**Built up**	**Hedgerow**	**Tree canopy**	**Wooded strip**	**Woodland**	**Water**	**Hedgerow**
Blwood	1	-	-	-	-	-	-	-	-	-
Conifwood	-	1	-	-	-	-	-	-	-	-
Freshwater	-	-	1	-	-	-	-	-	-	-
Builtup	-	-	-	1	-	-	-	-	-	-
Hedgerow	-	-	-	-	1	0.87	0.88	-	-	-
Treecanopy	-	-	-	-	0.87	1	0.95	-	-	-
Woodedstrip	-	-	-	-	0.88	0.95	1	-	-	-
Woodland distance	-	-	-	-	-	-	-	1	-	-
Water distance	-	-	-	-	-	-	-	-	1	-
Hedgerow distance	-	-	-	-	-	-	-	-	-	1

(b) 3-km radius (core sustenance zone for Leisler's bat, soprano pipistrelle and brown long-eared bat)

	Landscape scale (area)							**Local scale (distance to nearest)**		
	Blwood	**Conifwood**	**Freshwater**	**Built up**	**Hedgerow**	**Tree canopy**	**Wooded strip**	**Woodland**	**Water**	**Hedgerow**
Blwood	1	-	-	-	-	-	-	-	-	-
Conifwood	-	1	-	-	-	-	-	-	-	-
Freshwater	-	-	1	-	-	-	-	-	-	-
Builtup	-	-	-	1	-	-	-	-	-	-
Hedgerow	-	-	-	-	1	0.84	0.85	-	-	-
Treecanopy	-	-	-	-	0.84	1	0.94	-	-	-
Woodedstrip	-	-	-	-	0.85	0.94	1	-	-	-
Woodland distance	-	-	-	-	-	-	-	1	-	-
Water distance	-	-	-	-	-	-	-	-	1	-
Hedgerow distance	-	-	-	-	-	-	-	-	-	1

(c) 4-km radius (core sustenance zone for Natterer's bat, noctule and serotine)

	Landscape scale – area							Local scale – distance to nearest		
	Blwood	**Conifwood**	**Freshwater**	**Built up**	**Hedgerow**	**Tree canopy**	**Wooded strip**	**Woodland**	**Water**	**Hedgerow**
Blwood	1	-	-	-	0.75	-	0.74	-	-	-
Conifwood	-	1	-	-	-	-	-	-	-	-
Freshwater	-	-	1	-	-	-	-	-	-	-
Builtup	-	-	-	1	-	-	-	-	-	-
Hedgerow	0.75	-	-	-	1	0.84	0.87	-	-	-
Treecanopy	-	-	-	-	0.84	1	0.96	-	-	-
Woodedstrip	0.74	-	-	-	0.87	0.96	1	-	-	-
Woodland distance	-	-	-	-	-	-	-	1	-	-
Water distance	-	-	-	-	-	-	-	-	1	-
Hedgerow distance	-	-	-	-	-	-	-	-	-	1

(d) 6-km radius (core sustenance zone for barbastelle)

	Landscape scale – area							Local scale – distance to nearest		
	Blwood	**Conifwood**	**Freshwater**	**Built up**	**Hedgerow**	**Tree canopy**	**Wooded strip**	**Woodland**	**Water**	**Hedgerow**
Blwood	1	-	-	-	0.86	-	0.75	-	-	-
Conifwood	-	1	-	-	-	-	-	-	-	-
Freshwater	-	-	1	-	-	-	-	-	-	-
Builtup	-	-	-	1	-	-	-	-	-	-
Hedgerow	0.86	-	-	-	1	0.86	0.90	-	-	-
Treecanopy	-	-	-	-	0.86	1	0.97	-	-	-
Woodedstrip	0.75	-	-	-	0.90	0.97	1	-	-	-
Woodland distance	-	-	-	-	-	-	-	1	-	-
Water distance	-	-	-	-	-	-	-	-	1	-
Hedgerow distance	-	-	-	-	-	-	-	-	-	1

Table A2.3 Relationship between bat occurrence and three local habitat variables (distance to nearest hedgerow i.e. woody linear habitat, distance to nearest freshwater and distance to nearest woodland). Importantly these analyses also control for four landscape scale habitat variables (area of coniferous woodland, freshwater, built up area and hedgerow) within the mean-maximum foraging distance of the species as a buffer around each recording location. P-values are: *<0.05, **<0.01, ***<0.001. Significant results are further highlighted in bold. Columns are estimated coefficients for the predictors, and their standard errors.

Species	**Hedgerow**	**Freshwater**	**Woodland**
Daubenton's bat	-13.45 (3.2) ***	-3.2 (3.03)	-11.65 (2.84) ***
Natterer's bat	0.86 (0.29) **	0.93 (0.28) ***	1.08 (0.28) ***
Noctule	-2.19 (0.37) ***	-1.92 (0.35) ***	-2 (0.36) ***
Leisler's bat	1.32 (0.89)	0.3 (0.93)	2.21 (0.9) *
Serotine	3.54 (0.43) ***	3.69 (0.42) ***	3.88 (0.42) ***
Common pipistrelle	-21.24 (7.33) **	-16.18 (7.8) *	-22.33 (7.08) **
Soprano pipistrelle	-13.14 (1.41) ***	-5.54 (1.28) ***	-13.43 (1.46) ***
Brown long-eared bat	-1.67 (0.82) *	-1.37 (0.85)	-1.56 (0.82)
Barbastelle	-0.01 (0.03)	0 (0.03)	-0.02 (0.03)

Table A2.4 Relationship between bat activity as a proxy for abundance and three local habitat variables (distance to nearest hedgerow i.e. woody linear habitat, distance to nearest freshwater and distance to nearest woodland. Importantly these analyses also control for four landscape scale habitat variables (area of coniferous woodland, freshwater, built up area and hedgerow) within the mean-maximum foraging distance of the species as a buffer around each recording location. P-values are: *<0.05, **<0.01, ***<0.001. Significant results are further highlighted in bold. Columns are estimated coefficients for the predictors, and their standard errors.

Species	Hedgerow	Freshwater	Woodland
Daubenton's bat	0.39 (0.32)	-0.22 (0.48)	-0.41 (0.46)
Natterer's bat	0.11 (0.3)	0.21 (0.29)	-0.59 (0.44)
Noctule	0.2 (0.09) *	-0.6 (0.23) **	0.63 (0.22) **
Leisler's bat	-0.26 (0.41)	0.34 (0.3)	0.02 (0.35)
Serotine	-0.74 (0.32) *	-0.57 (0.33)	-0.43 (0.48)
Common pipistrelle	-0.35 (0.27)	-0.25 (0.2)	-0.31 (0.22)
Soprano pipistrelle	0.56 (0.22) *	-1.32 (0.26) ***	0.08 (0.33)
Brown long-eared bat	-0.27 (0.19)	-0.08 (0.15)	0.09 (0.18)
Barbastelle	-3.68 (1.6) *	0.12 (0.26)	-1.04 (0.6)

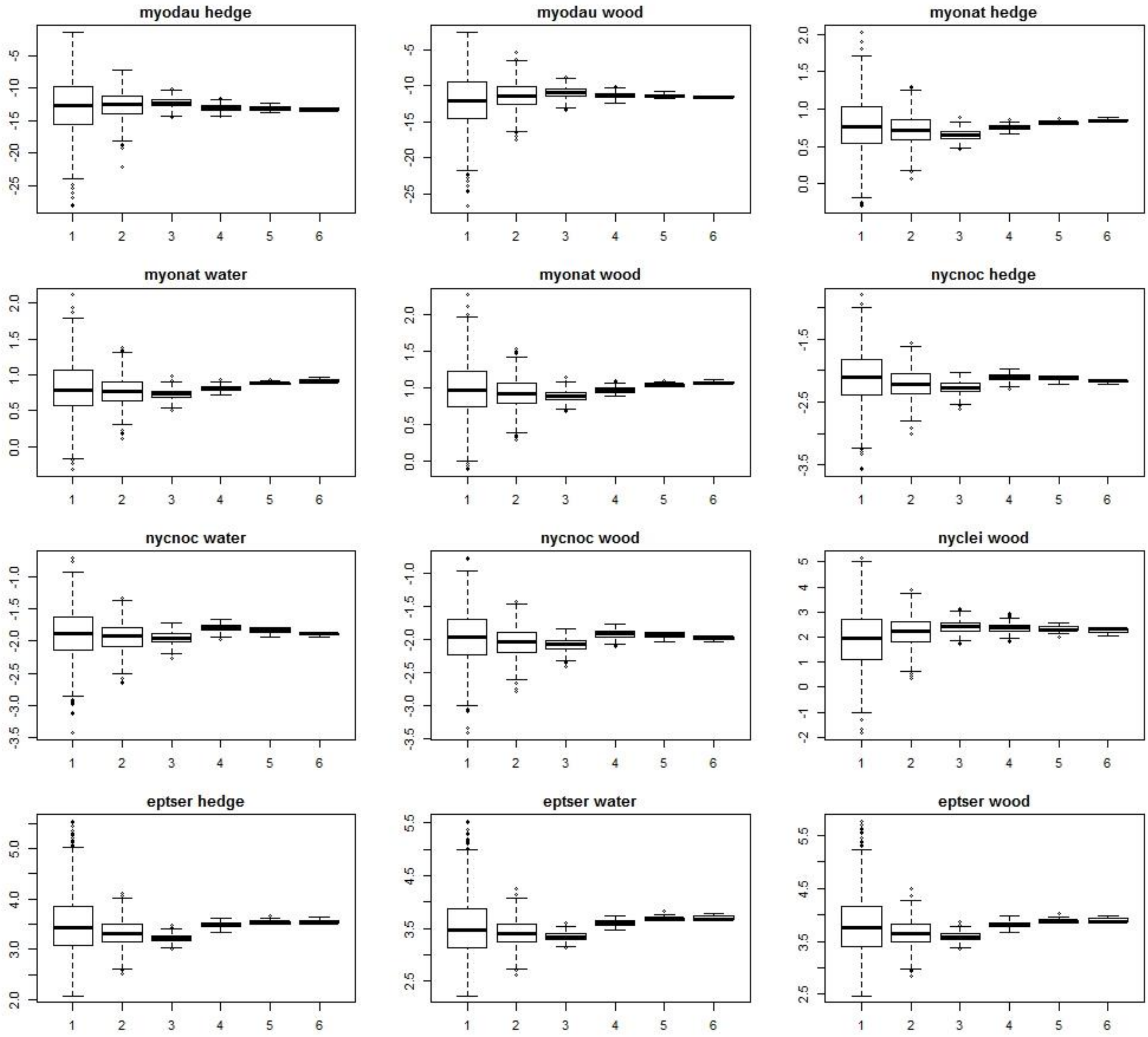
Table A2.5 Relationship between bat occurrence and local habitat variables for June-July and August-September. These analyses also control for four landscape scale habitat variables (area of coniferous woodland, freshwater, built up area and hedgerow) within the mean-maximum foraging distance of the species as a buffer around each recording location. P-values are: *<0.05, **<0.01, ***<0.001. Significant results are further highlighted in bold. Columns are estimated coefficients for the predictors, and their standard errors.

Species	**Hedgerow**		**Freshwater**		**Woodland**	
	Early season	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**
Daubenton's bat	-11.45 (5.21) *	-20.54 (4.74) ***	-1.87 (4.66)	-6.49 (4.92)	-11.81 (4.74) *	-18.32 (4.34) ***
Natterer's bat	1.21 (0.4) **	0.62 (0.44)	1.35 (0.4) ***	0.65 (0.43)	1.42 (0.39) ***	0.83 (0.42)
Noctule	-1.72 (0.47) ***	-2.97 (0.63) ***	-1.07 (0.44) *	-2.98 (0.61) ***	-1.28 (0.45) **	-3.05 (0.64) ***
Leisler's bat	1.11 (1.25)	2.41 (1.36)	1.15 (1.23)	-1.7 (1.64)	1.82 (1.21)	3.82 (1.46) **
Serotine	2.92 (0.52) ***	4.55 (0.76) ***	3.4 (0.52) ***	4.36 (0.75) ***	3.58 (0.52) ***	4.67 (0.75) ***
Common pipistrelle	-1.46 (16.09)	-31.39 (10.4) **	-9.75 (14.99)	-19.98 (11.4)	-3.4 (14.67)	-31.97 (10.05) **
Soprano pipistrelle	-10.96 (1.67) ***	-17.05 (2.92) ***	-3.08 (1.57)	-10.92 (2.58) ***	-11.31 (1.68) ***	-18.2 (3.26) ***
Brown long-eared bat	-1.91 (1.21)	-1.66 (1.21)	-1.94 (1.18)	-0.64 (1.38)	-1.03 (1.17)	-1.98 (1.23)
Barbastelle	-0.01 (0.05)	0 (0.05)	0.05 (0.05)	-0.02 (0.05)	-0.01 (0.05)	

Table A2.6 Relationship between bat activity and local habitat variables for June-July (early season) and August-September (late season). These analyses also control for four landscape scale habitat variables (area of coniferous woodland, freshwater, built up area and hedgerow) within the mean-maximum foraging distance of the species as a buffer around each recording location. P-values are: *<0.05, **<0.01, ***<0.001. Significant results are further highlighted in bold. Columns are estimated coefficients for the predictors, and their standard errors.

Species	**Hedgerow**		**Freshwater**		**Woodland**	
	Early season	**Late season**	**Early season**	**Late season**	**Early season**	**Late season**
Daubenton's bat	0.34 (0.55)	0.37 (0.21)	-0.11 (0.63)	-1.34 (0.49) **	-0.57 (0.68)	-0.1 (0.38)
Natterer's bat	0.1 (0.42)	0.21 (0.31)	0.2 (0.39)	0.15 (0.37)	-0.45 (0.58)	-0.82 (0.49)
Noctule	0.26 (0.11) *	0.17 (0.14)	-0.44 (0.29)	-0.78 (0.38) *	0.8 (0.27) **	0.41 (0.39)
Leisler's bat	0 (0.48)	-0.61 (0.6)	0.28 (0.38)	0.63 (0.4)	-0.07 (0.47)	0.12 (0.46)
Serotine	-0.92 (0.46) *	-0.51 (0.43)	-0.3 (0.33)	-2.59 (1.67)	-0.74 (0.62)	0.17 (0.7)
Common pipistrelle	-0.65 (0.36)	0.01 (0.32)	-0.2 (0.24)	-0.21 (0.32)	-0.2 (0.24)	-0.42 (0.39)
Soprano pipistrelle	-0.49 (0.4)	0.61 (0.23) **	-1.56 (0.42) ***	-1.68 (0.37) ***	-0.25 (0.43)	0.31 (0.47)
Brown long-eared bat	-0.11 (0.22)	-0.48 (0.29)	0.02 (0.18)	-0.3 (0.25)	-0.22 (0.26)	0.25 (0.26)
Barbastelle	-1.51 (0.74) *	-7.34 (71.87)	0.62 (0.25) *	0.13 (0.36)	-1.29 (0.56) *	-1.09 (0.82)

Figure A2.1 Results from random resampling from the full dataset to select choose 1-6 nights of recording within sampling occasion, and its influence on model coefficients for occurrence models. Each graph shows the range of results from the resampling: the central bar is the median, the box shows the inter-quartile range and the dashed bars show 1.5 times the interquartile range, with outliers shown as dots. Continued on next page.



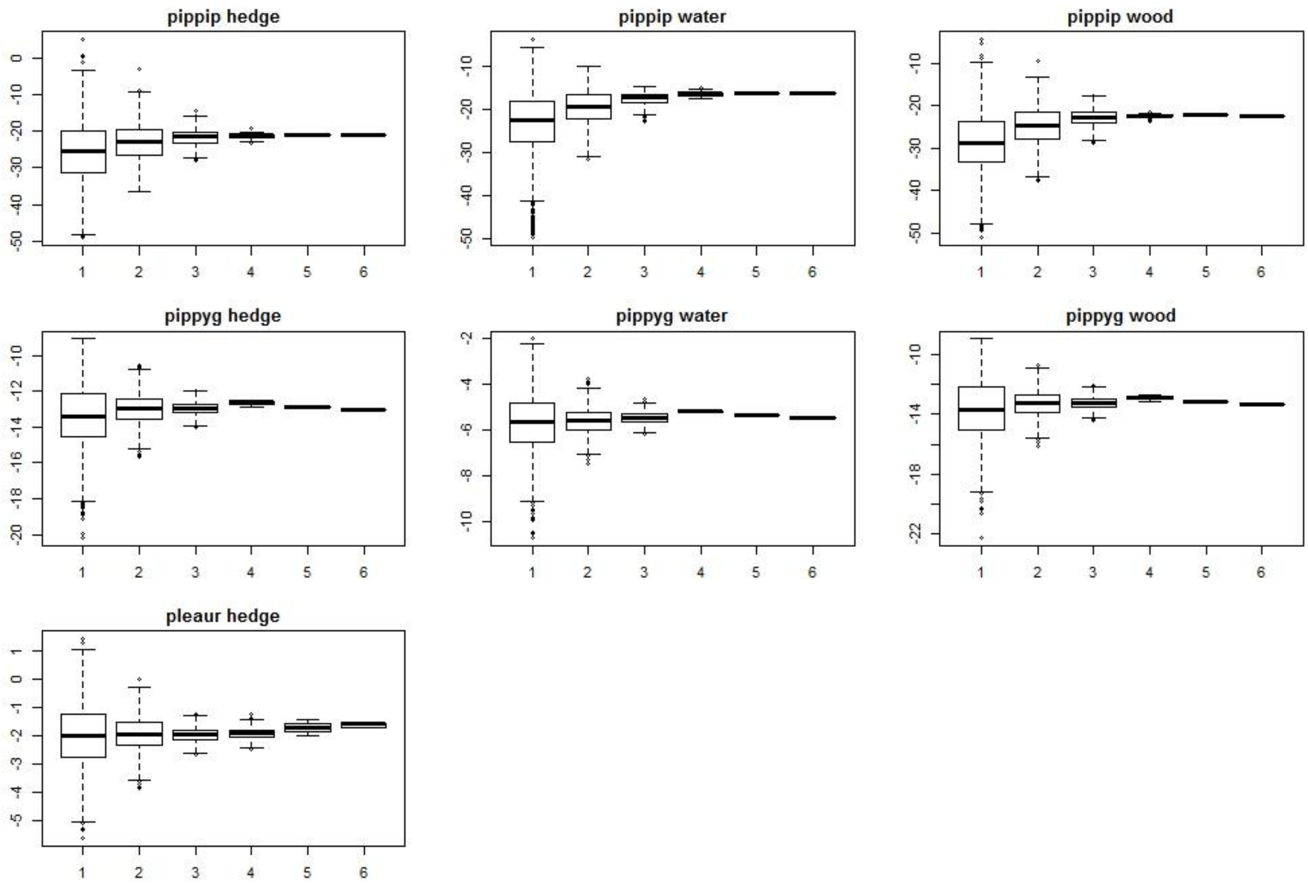

pippip hedge
pippip water
pippip wood
pippyg hedge
pippyg water
pippyg wood
pleaur hedge

Figure A2.2 Results from random resampling from the full dataset to select choose 1-6 nights of recording within sampling occasion, and its influence on model coefficients for activity models. Each graph shows the range of results from the resampling: the central bar is the median, the box shows the inter-quartile range and the dashed bars show 1.5 times the interquartile range, with outliers shown as dots.

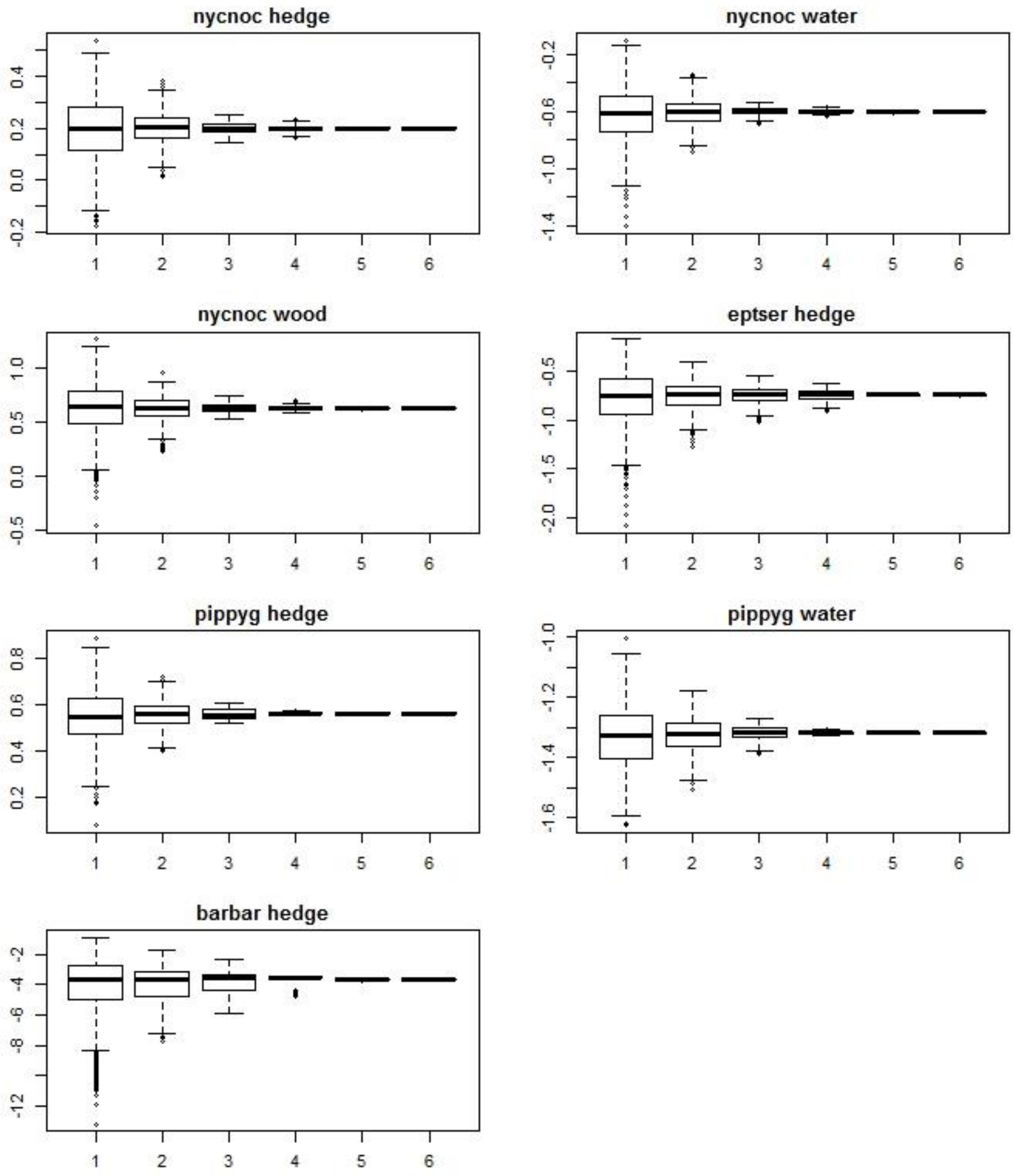
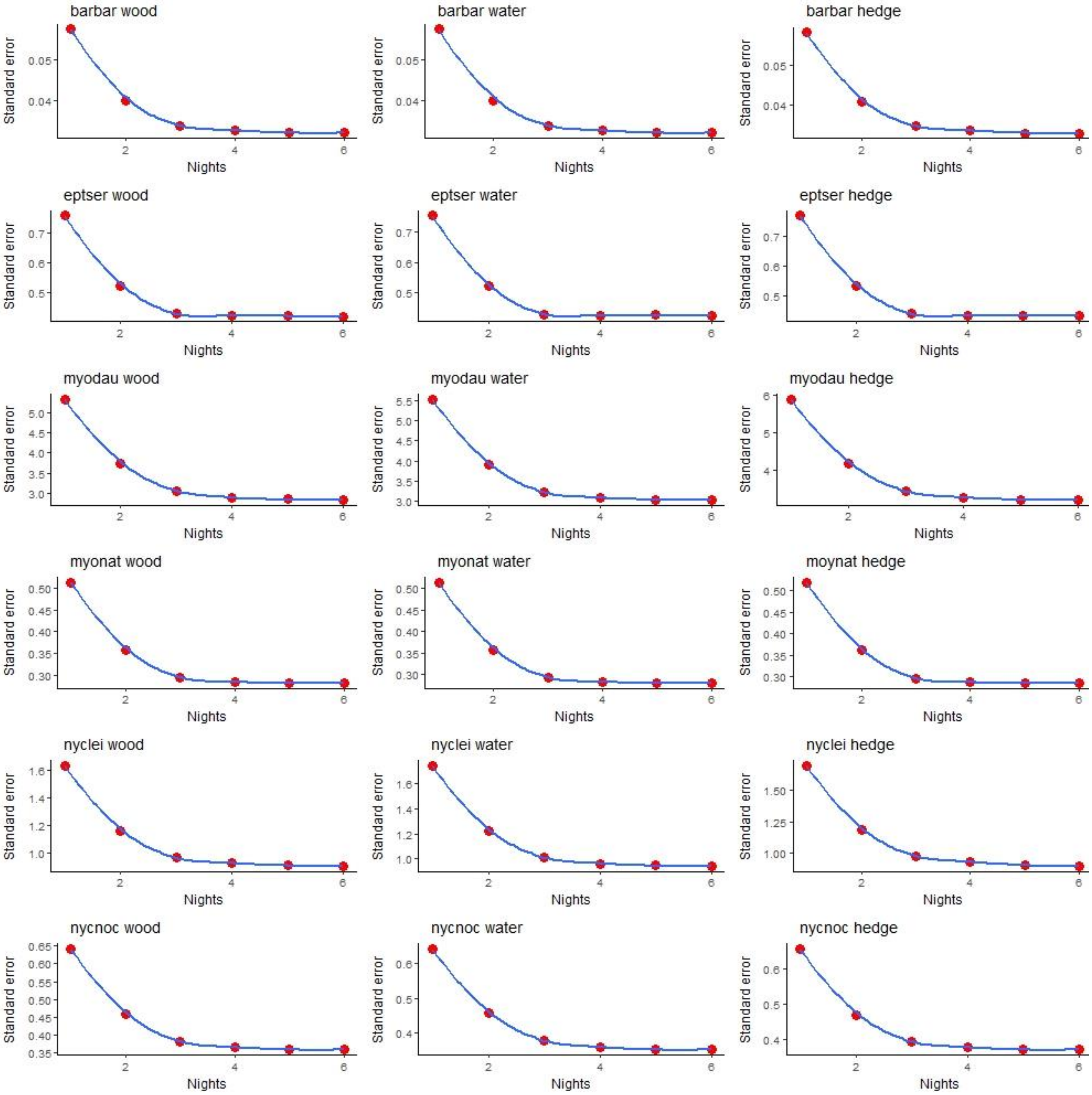


Figure A2.3 Results from random resampling from the full data to select 1-6 nights of recording within sampling occasion, and its influence of standard error of model coefficients for occurrence models. Each graph shows the mean standard error with increase nights of recording. Continued on the next page.



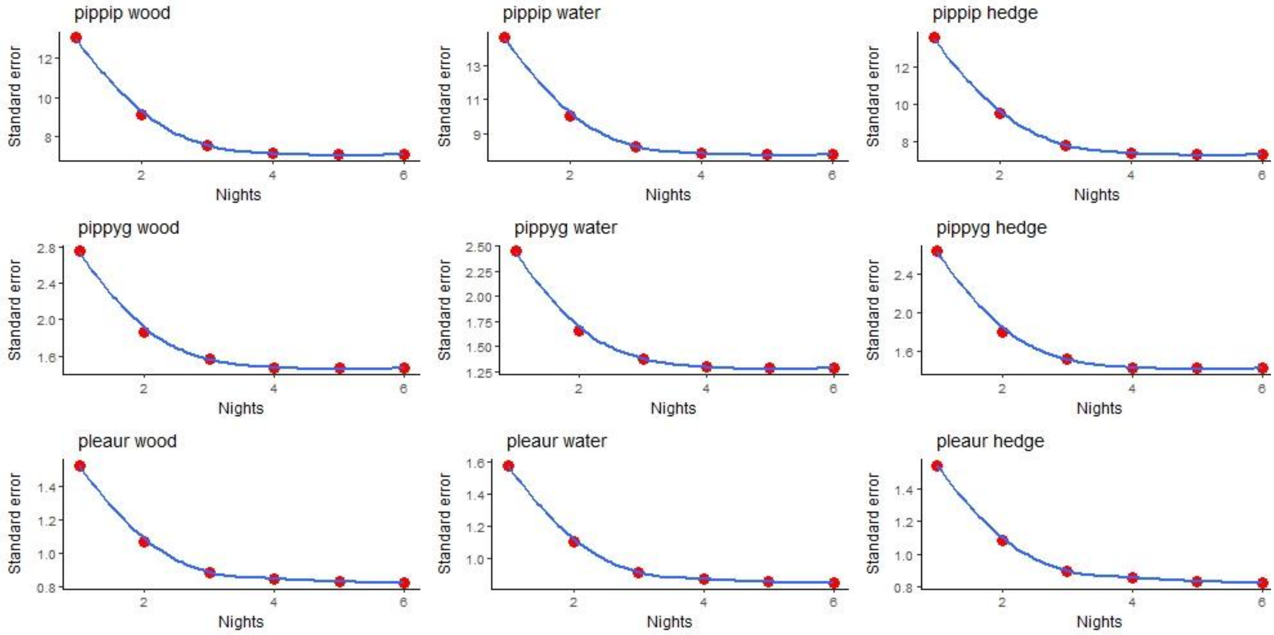
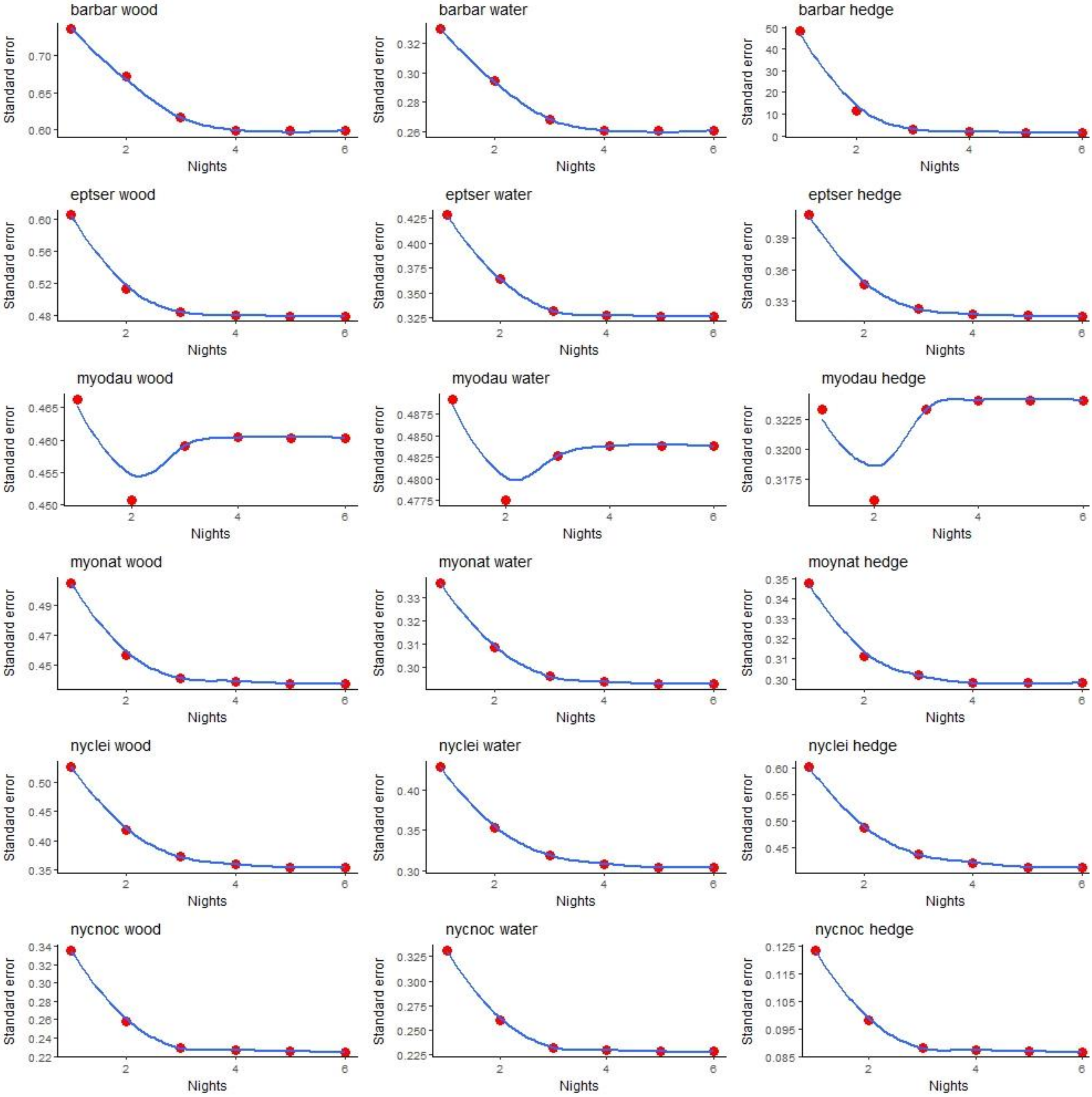

pippip wood
pippip water
pippip hedge
pippyg wood
pippyg water
pippyg hedge
pleaur wood
pleaur water
pleaur hedge
Standard error
Nights

Figure A2.4 Results from random resampling from the full data to select 1-6 nights of recording within sampling occasion, and its influence of standard error of model coefficients for activity models. Each graph shows the mean standard error with increase nights of recording. Continued on the next page.



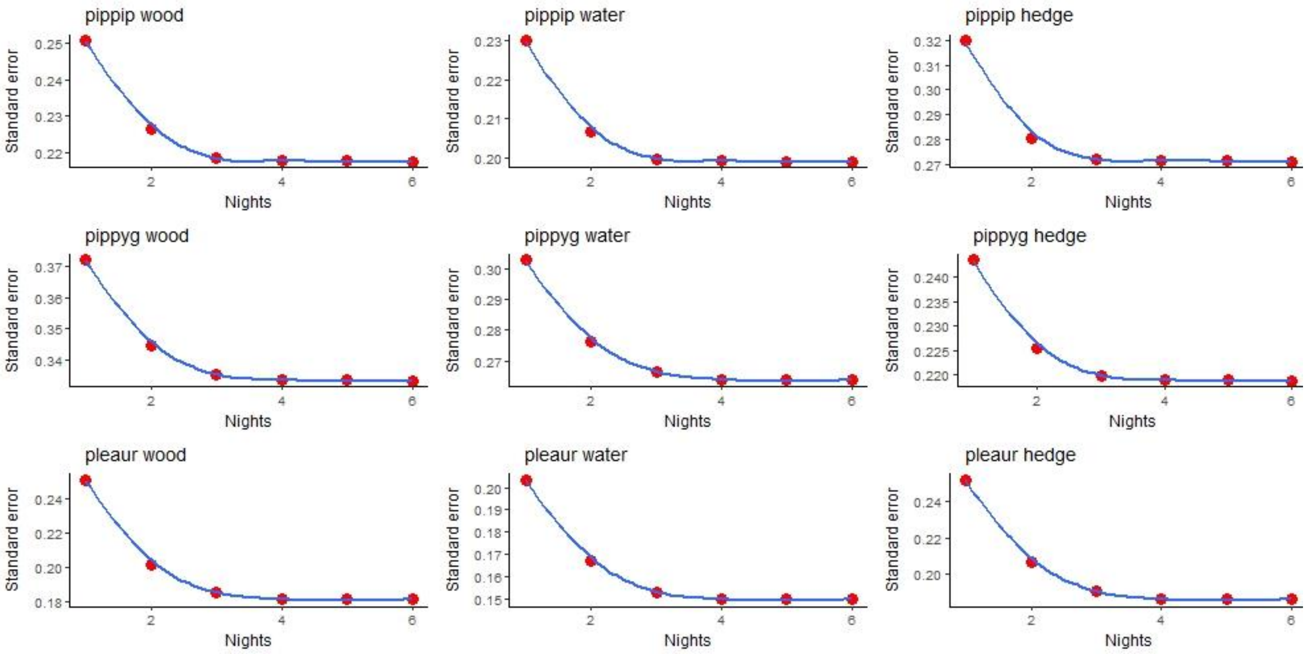
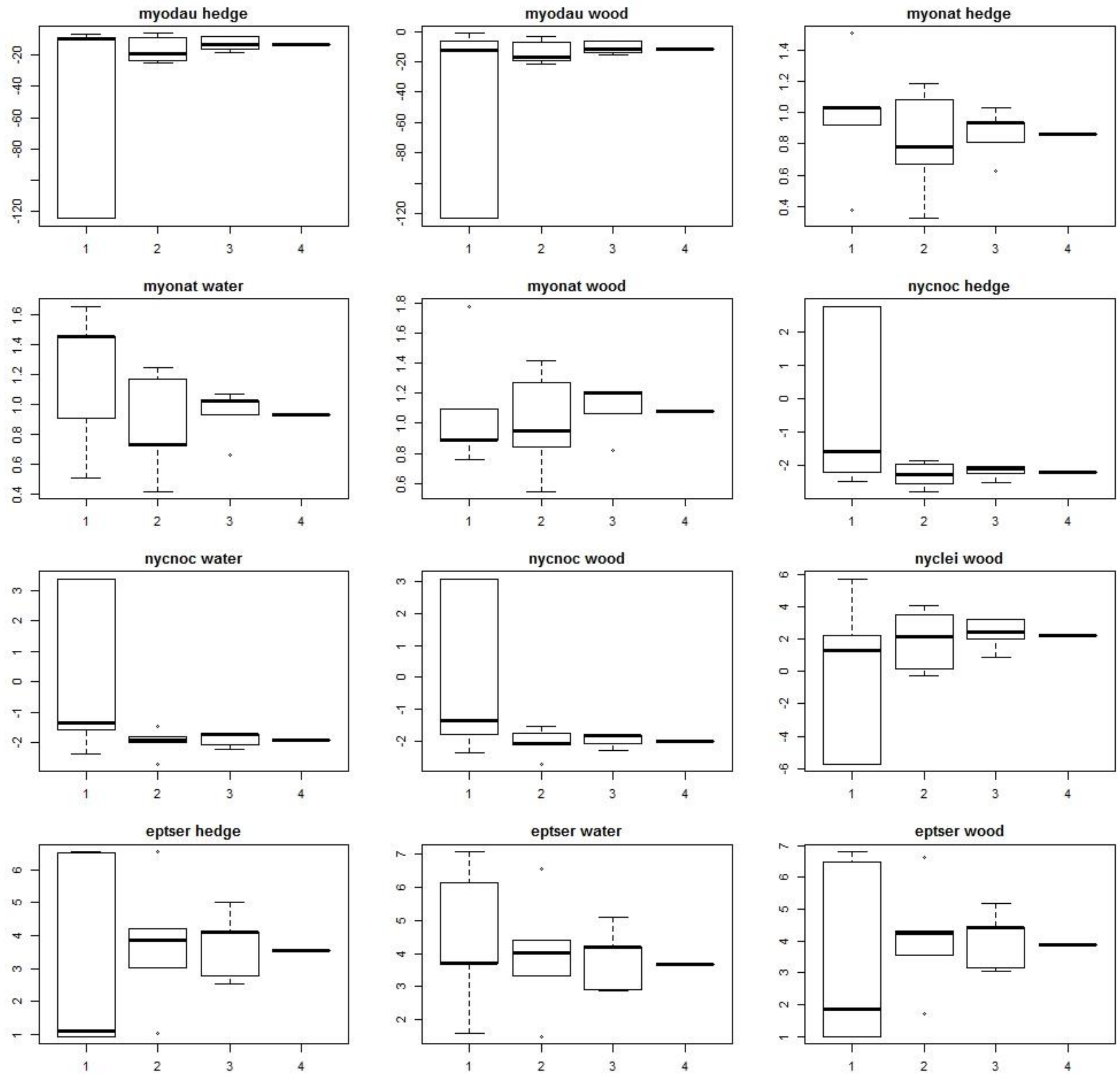

pippip wood
pippip water
pippip hedge
pippyg wood
pippyg water
pippyg hedge
pleaur wood
pleaur water
pleaur hedge
Standard error
Nights

Figure A2.5 Results from random resampling from the full dataset to select choose 1-4 sampling occasions, and its influence on model coefficients for occurrence models. Each graph shows the range of results from the resampling: the central bar is the median, the box shows the inter-quartile range and the dashed bars show 1.5 times the interquartile range, with outliers shown as dots. Continued on next page.



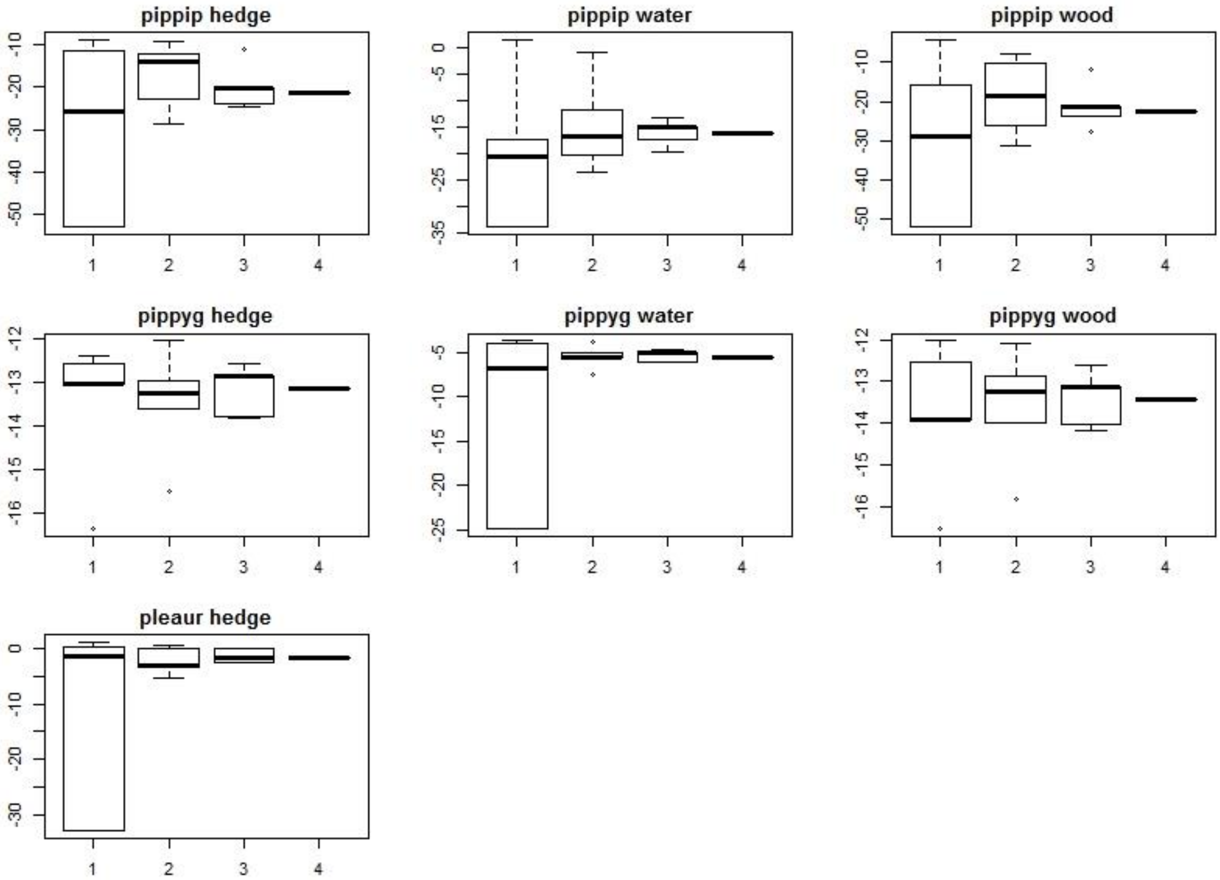

pippip hedge
pippip water
pippip wood
pippyg hedge
pippyg water
pippyg wood
pleaur hedge
1
2
3
4

Figure A2.6 Results from random resampling from the full dataset to select choose 1-4 sampling occasions, and its influence on model coefficients for activity models. Each graph shows the range of results from the resampling: the central bar is the median, the box shows the inter-quartile range and the dashed bars show 1.5 times the interquartile range, with outliers shown as dots.

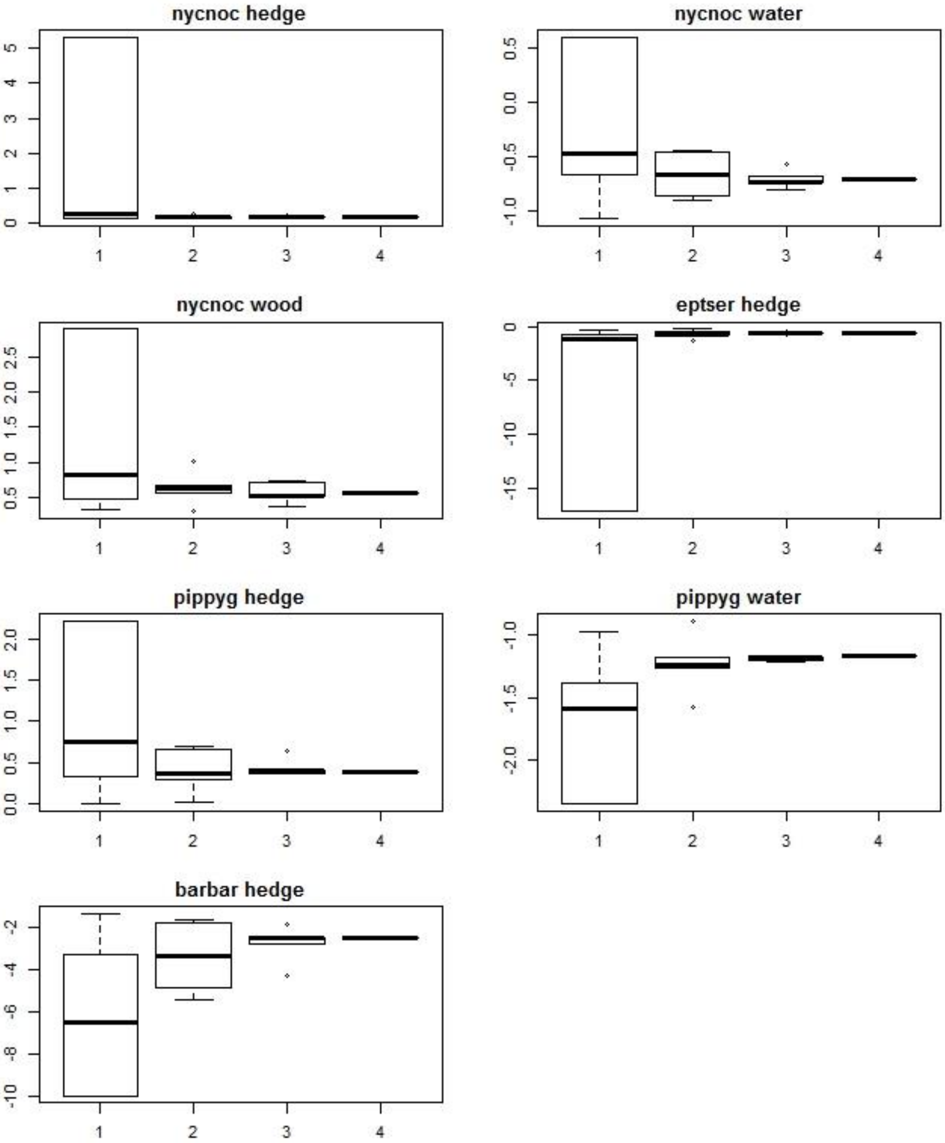
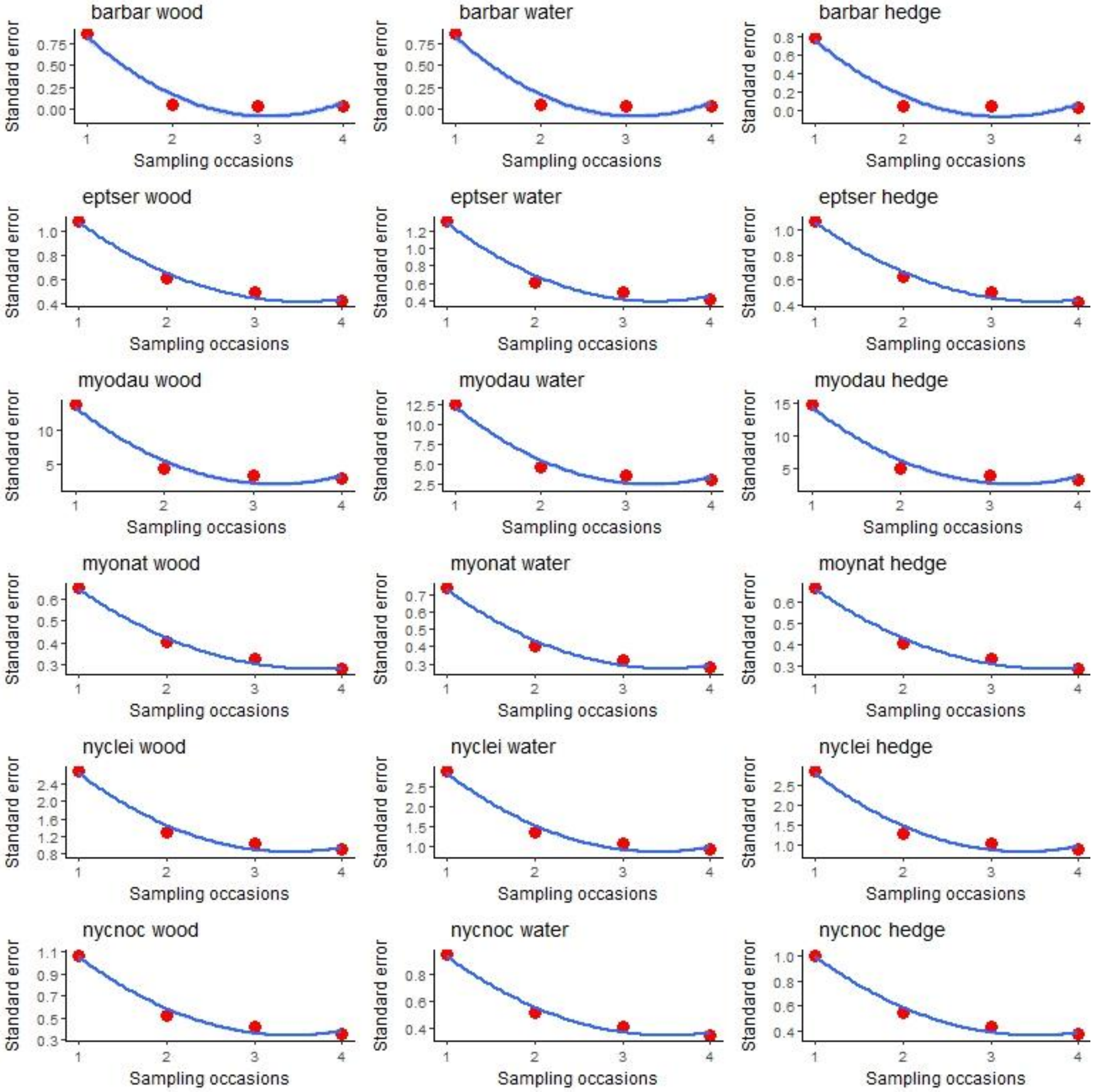


Figure A2.7 Results from random resampling from the full data to select 1-4 sampling occasions, and its influence of standard error of model coefficients for occurrence models. Each graph shows the mean standard error with increase nights of recording. Continued on next page.



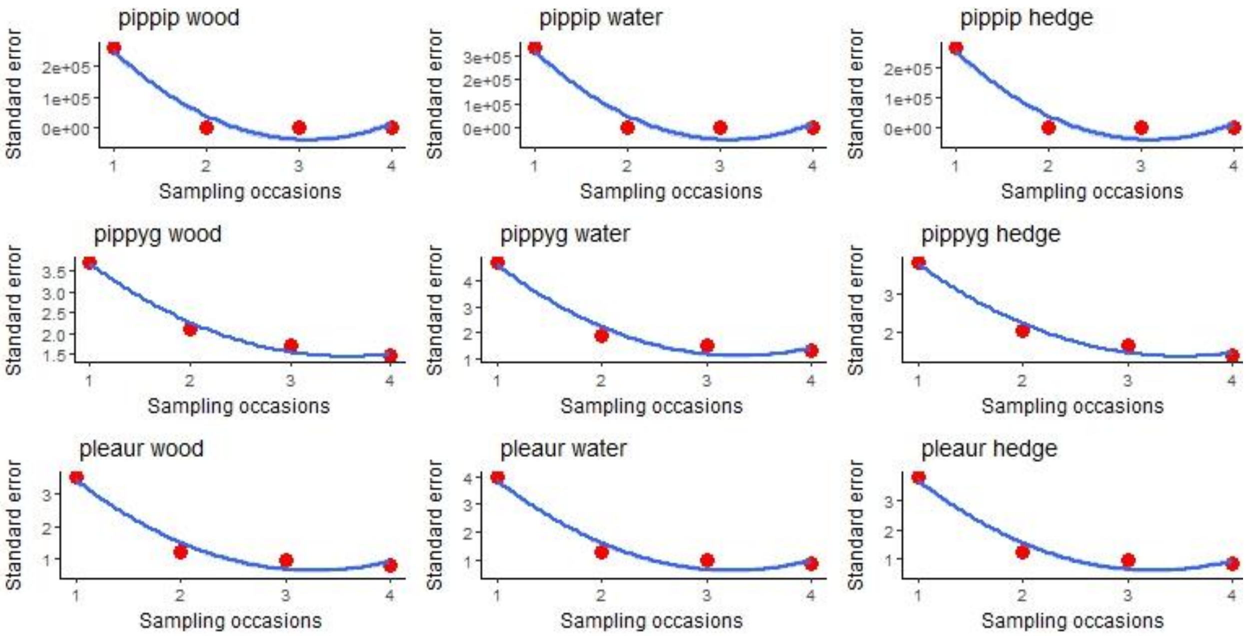
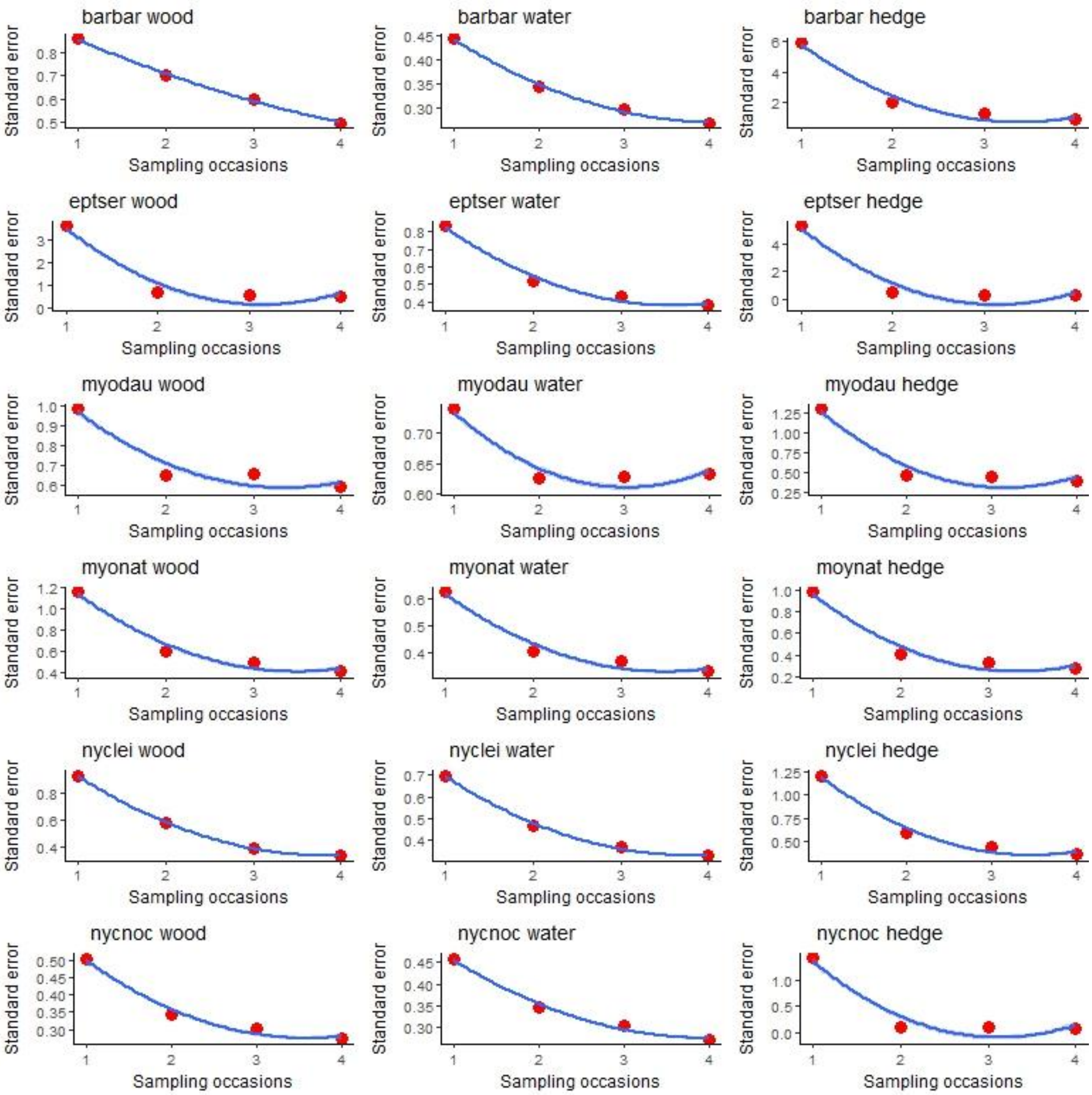
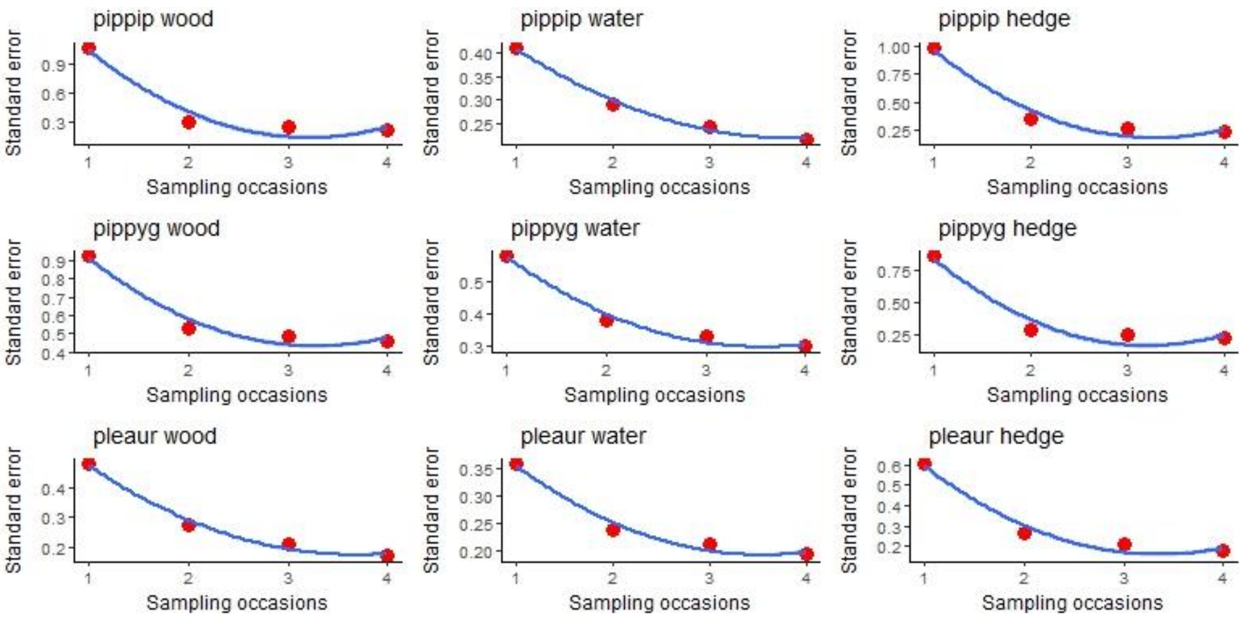

pippip wood
pippip water
pippip hedge
pippyg wood
pippyg water
pippyg hedge
pleaur wood
pleaur water
pleaur hedge
Standard error
Sampling occasions

Figure A2.8 Results from random resampling from the full data to select 1-4 sampling occasions, and its influence of standard error of model coefficients for activity models. Each graph shows the mean standard error with increase nights of recording. Continued on next page.




pippip wood
pippip water
pippip hedge
pippyg wood
pippyg water
pippyg hedge
pleaur wood
pleaur water
pleaur hedge
Standard error
Sampling occasions

A3 Data handling and trait collation prior to analyses

A3.1 Insect data handling

The sections below detail how the minority of aggregated insect records were processed prior to analyses of species richness and diversity, for each insect taxa. For a summary of the broad approach to handling insect data, see the main report Section 2.5.

A3.1.1 Butterflies

Three aggregate taxa were recorded (Pearl-bordered/Small Pearl-bordered Fritillary, Small/Essex Skipper, Green-veined/Small White) and occasionally butterflies were recorded in an "Other butterflies" category. For the Pearl-bordered and Small Pearl-bordered Fritillaries we aggregated all records to the Pearl-bordered/Small Pearl-bordered Fritillary aggregate class for analysis of richness and diversity. For the skipper and white aggregates we had many more observations of the individual species, therefore we used the proportion of individuals observed within the square or NCA in that year to allocate the individuals recorded to aggregate to one of the constituent species.

A3.1.2 Bees

Bumblebees from transects

Bumblebees recorded as *B. terrestris, B. lucorum* or *B. lucorum/terrestris* were all merged into the aggregate *B. lucorum/terrestris* prior to richness and diversity analyses. We were unable to use the proportional allocation procedure because we had no workers allocated to species as these two species are very difficult to identify as workers. It may not be appropriate to assume that the ratios of queens and males observed would be the same as the ratios of workers.

Bees from pan traps

Pan trap bees are identified under a microscope, so it was possible to identify workers of *B. lucorum* and *B. terrestris.* We could therefore use proportions of these species level identifications to allocate any records of the aggregate *B. lucorum/terrestris* to either *B. terrestris* or *B. lucorum* sensu lato.

Two cryptic species of bumblebee were recorded from pan traps which were not recorded on transect surveys (*B. cryptarum* and *B. magnus*). These taxa are very challenging to identify and therefore we merged all observations with those of *B. lucorum* to a *B. lucorum* sensu lato class.

A single record of a bee identified to either *B. hortorum* or *B. ruderatus* was made, from a worn specimen. This record was included in abundance analyses but excluded from richness and diversity analyses.

Solitary bees and honeybees were all recorded to species.

A3.1.3 Hoverflies

Female *Sphaerophoria* cannot be recorded to species and were therefore observed as *Sphaerophoria* females ident. For analyses, these individuals were only included towards richness and diversity when no other *Sphaerophoria* were recorded in that square, to avoid double counting.

A few *Heringia* individuals could not be recorded to species, these were removed from species richness and diversity calculations.

Several aggregate taxa were also recorded. *Cheilosia albitarus* sensu lato was considered to belong to *Chelosia albitarus* as no *Chelosia ranunculi* were recorded, with which females could potentially be confused. Similarly, *Platycheirus peltatus* agg. were assumed to belong to

Platycheirus peltatus as neither *P. amplus* nor *P. nielsensi* were recorded. *Platycheirus scutatus* sensu lato were assigned to *Platycheirus scutatus* as *P. splendicus* was not recorded in the survey.

A3.1.4 Moths

Three moth aggregates were recorded where similar species could not be separated. *Mesapamea secalis* and *Mesapamea didyma* were both recorded as was the aggregate *Mesapamea didyma/secalis*. All records were analysed as the aggregate as species level identification requires dissection which was not feasible with so many individuals recorded. *Yponomeuta padella*, *Y. malinellus* and *Y. cagnagella* require dissection for identification and all were therefore combined as the aggregate *Y. padella/malinellus/cagnagella* for analysis along with any records of *Yponomeuta* spp.

The aggregate *Aethes cnicana/rubigana* was excluded from species richness and diversity calculations.

A number of moths were only identified to genus or higher taxonomic level. Generally these were excluded from richness and diversity analyses to avoid double counting, except where no other individuals of that genus were recorded e.g. *Ochsenheimeria* spp.

A3.2 Insect trait descriptions

A3.2.1 Butterfly traits

The majority of butterfly traits were collated using information from Dennis (2010). These include:

- Strategy – whether a species of the wider countryside or a specialist habitat species.
- Voltinism – categorised as 1 (univoltine) or 2 (partial bivoltine, bivoltine or multivoltine).
- Flight time – categorised as 1 (adults first recorded in April or earlier in year) or 2 (adults first recorded in May or later in year).
- Larval food plant types (grass, forb, woody or other).
- Diet breadth - the number of larval core host plant species were categorised as 1 (larva feeds on 1 or 2 core host plant species) or 2 (larva feeds on 3 or more core host plant species)

Wingspan (as a proxy for mobility) was collated using data on the the UK butterflies website (http://www.ukbutterflies.co.uk/index.php).

The conservation status of species followed the Red List categories given in Fox & Dennis (2021) and were listed for those species categorised as 'Critically Endangered', 'Endangered', 'Vulnerable' or 'Near threatened'. Species were attributed 1 where a Red List category had been assigned in the previous column.

Table A3.1 below has more detailed butterfly trait descriptions and source references.

Table A3.1 Butterfly trait definitions, groups and data source details

Trait	Category	Category descriptions/definitions	Notes	Trait data sources
Strategy	Wider countryside			Dennis (2010) Appendix 4)
	Habitat specialist			
Mobility (average wingspan in mm)	1	Small (≤ 38 mm)	Derived from the average (across gender) wingspan.	UK butterflies website http://www.ukbutterflies.co.uk/index.php
	2	Medium (39 – 59 mm)		
	3	Large (≥ 60 mm)		
Voltinism	1	Univoltine – single generation per year		Dennis (2010) Appendix 4
	2	Partial bivoltine, bivoltine or multivoltine – more than one generation per year		
Flight time	1	Adults first recorded in flight in April or earlier in year (early/spring flying species)	For multivoltine species this is based on the first appearance in the calendar year.	
	2	Adults first recorded in flight in May or later in year (late/summer flying species)		
Larval host type - Grass	1	Larval food plant = grass		
Larval host type - Forb	1	Larval food plant = forb		
Larval host type - Woody	1	Larval food plant = woody		
Larval host type - Other	1	Larval food plant not grass, forb or woody species		
Larval host plant breadth	1	Larva feeds on 1 or 2 core host plant species		
	2	Larva feeds on 3 or more core host plant species		
Pest species	1	Two Pieris species that feed mainly on Brassicas		
	2	All other butterfly species		
Conservation status	1	Regionally Extinct		Fox & Dennis (2021) https://doi.org/10.5281/zenodo.5710786
	1	Critically Endangered		
	1	Endangered		
	1	Vulnerable		
	1	Near threatened		

A3.2.2 Bee traits

Bee traits were collected using information from a range of published sources. Data was also collated from currently unpublished trait databases compiled by experts from UKCEH (Ben Woodcock, pers. comm.) and the Bees, Wasps and Ants Recording Society (BWARS) (Mike Edwards, pers. comm. These include:

- Voltinism – categorised as 1 (univoltine) or 2 (partial bivoltine, bivoltine or triple cycle overlap).

These traits were taken directly from the BWARS website (www.bwars.com)

- Diet breadth – categorised as 1 (oligolectic) or 2 (polylectic).
- Sociality – categorised as P (cleptoparasitic), S (solitary) or E (eusocial at least sometimes (eusocial or facultatively eusocial)).

One species had missing trait data from the Woodcock & Edwards unpublished trait database so information was taken from the BWARS website.

Flight times were taken from Falk & Lewington (2015) and categorised as 1 (first on wing in April or earlier) or 2 (first on wing in May or later).

Tongue length traits were only collated for bumblebee species because equivalent tongue length categories are not available for other bee species. Tongue lengths were categorised as short, mid or long and derived from five published sources: Edwards & Jenner (2009), Gammans et al. (2018), Goulson & Darvill (2004), Goulson et al. (2008) and Prys-Jones & Corbett (2011).

Average forewing lengths were derived from Falk and Lewington (2015) using the average lengths across castes and gender. For bumblebee-only analyses, average forewing lengths were categorised as 1 (<13 mm) or 2 (≥ 13 mm). For analyses of all bees, average forewing lengths were categorised as 1 (<5.4mm), 2 (5.5 - 9 mm) or 3 (>9 mm).

Cuckoobee species were categorised as ‘Y’ using Gammans et al. (2018).

Dominant crop polliantors - six wild bee species most frequently recorded as dominant crop pollinators from Dicks et al. (2015).

Conservation status was assigned to those species listed as ‘Critically Endangered’, ‘Endangered’, ‘Vulnerable’ or ‘Near threatened’ in accordance with the IUCN Red list categories (JNCC/Natural England, provisional unpublished Hymenoptera Red List, courtesy of Jon Curson Natural England)

Table A3.2 below has more detailed bee trait descriptions and source references.

Table A3.2 Bee (bumblebee and solitary bee) trait definitions, groups and data source details

Trait	Category	Category descriptions/definitions	Notes	Trait data sources
Flight time	1	First on the wing in April or earlier		Falk & Lewington (2015)
	2	First on the wing in May or later		
Diet breadth (excluding bumblebees and parasitic species)	1	Oligolectic – forages on pollen from a single family of host plants	Excludes bumblebees as all are polylectic and parasitic species	
	2	Polylectic – forages on pollen from a range of host plants from many families		
Voltinism	1	Univoltine – single generation per year		Unpublished bee trait database, Woodcock & Edwards (pers. comm.)
	2	Partial bivoltine, bivoltine or triple cycle overlap – more than one generation per year		
Sociality	P	Cleptoparasitic – (cuckoobees) invade the nest of solitary bees.	Pan trap bee analyses only	BWARS website
	S	Solitary – bees that do not live in colonies		
	E	Eusocial at least sometimes (eusocial or facultatively eusocial) – advanced form of social bees, possessing a worker caste		
Bumblebee tongue length	Short	Defined from five data sources	Only bumblebee species	Edwards & Jenner (2009) Gammans et al. (2018) Goulson & Darvill (2004) Goulson et al. (2008) Prys-Jones & Corbett (2011)
	Mid			
	Long			
Cuckoo species vs. social species	Y	If a cuckoo species	Only bumblebee species	Gammans et al. (2018)
		If a social species		
Bumblebees: forewing length (mm)	1	< 13 mm	Derived from average (across castes/gender) forewing lengths	Falk & Lewington (2015)
	2	≥ 13 mm		
All bees: forewing length (mm)	1	<5.4 mm	Derived from average (across castes/gender) forewing lengths	
	2	5.5 - 9 mm		
	3	>9 mm		
Conservation status	1	Critically Endangered		JNCC/Natural England, provisional unpublished Hymenoptera Red List, courtesy of Jon Curson Natural England
	1	Endangered		
	1	Vulnerable		
	1	Near threatened		
Dominant crop pollinators	1	Y	6 bees frequently recorded as dominant crop visitors	Dicks et al., 2015

A3.2.3 Hoverfly traits

The Hoverfly traits were mainly collated using the Syrph the Net (StN) database of European syrphid species by Speight et al. (2016). These include:

- Larval food type – categorised as 1 (predatory), 2 (herbivorous) or 3 (detritivorous);
- Voltinism – categorised as 1 (univoltine) or 2 (multivoltine); and
- Flight time – categorised as 1 for early/spring flying species (April and earlier) or 2 for late/summer flying species (May onwards)
-

Average wing lengths were taken from Stubbs & Falk (2002) and categorised as 1 (small), 2 (medium) or 3 (large).

Table A3.3 below has more detailed hoverfly trait descriptions and source references.

A3.2.4 Combined bee and hoverfly trait groups

In addition to the separate bee and hoverfly traits, two combined groupings of hoverfly and bee species were used in trait analyses. These were taken from the Design and Testing of a National Pollinator and Pollination Monitoring Framework report (Carvell et al., 2016).

- Crop visitors - 19 bee and hoverfly species identified as important crop pollinators for the National Pollinator Monitoring Scheme (PoMS)
- Monitoring candidate species - 37 bee and hoverfly species identified as candidates for PoMS monitoring

Table A3.3 Hoverfly trait definitions, groups and data source details

Trait	Category	Category descriptions/definitions	Notes	Trait data sources
Mobility (wing length in mm)	1	Small (< 6.5 mm)	The midpoint between min and max wing lengths was used to calculate average wing lengths	Stubbs & Falk (2002)
	2	Medium (6.5-8.5 mm)		
	3	Large (> 8.5 mm)		
Larval food source	1	Predatory – those that feed on living animals, mostly aphids)	Where a species was known to feed across two of these categories it was generally found the detritivorous part was 'in addition to' so these were categorised as predatory or herbivorous respectively, rather than detritivorous, unless stated in the text that detritus feeding was known to be the main food source.	Speight et al. (2016)
	2	Herbivorous – those that feed on living plant matter including any part of the plant (includes bulb and root feeders)		
	3	Detritivorous – those that feed on decaying matter and/or the associated microorganisms.		
Flight time	1	Adults first recorded in flight in April or earlier in year (early/spring flying species)	For multivoltine species this is based on the first appearance in the calendar year.	
	2	Adults first recorded in flight in May or later in year (late/summer flying species)		
Voltinism	1	Univoltine – one distinct generation in a calendar year.		
	2	Multivoltine – all species showing any flexibility in voltinism beyond a single generation.	Understanding that some of these species may only produce one generation in cooler years and/or in higher altitudes and latitudes.	

A 3.2.5 Moth traits

No existing trait database or single source of trait information was available for moths. Traits were collated for the 925 moth species recorded on LandSpAES using a range of published and online sources with priority given to more recently published sources. A wider selection of reference material was required to compile micro-moth traits due to the limited range of data available for some species (mainly micro-moths).

The macro-moth traits were collated using data from Waring et al. (2017). Micro-moth data was taken from Sterling et al. (2012), however this source does not comprehensively cover all micro-moth species, therefore, data was also collated using Emmet & Heath (1991) or taken from UKMoths (www.ukmoths.org.uk). These include:

- Larval host plant type – categorised as grasses (grasses, sedges and rushes), forbs (herbaceous plants), woody (trees and shrubs) or other (includes mosses, lichens/algae, fungi, animal matter, decaying plant matter, stored goods).
- Larval host specificity – categorised as 1 (monophagous), 2 (oligophagous) or 3, (polyphagous).
- Voltinism – categorised as 1 (obligate univoltine) or 2 (multivoltine or variable multivoltine). Where a species is known to be univoltine in the north but multivoltine/variable multivoltine in the south, the latter category takes precedence and the species assigned to category 2.
- Flight time – categorised as 1 for early/spring flying species (April or earlier) or 2 for late/summer flying species (May onwards). Overwintering adult species were categorised according to their first appearance in the calendar year.

The average forewing length was categorised as 1 (small), 2 (medium) or 3 (large) and calculated using the average of the range provided in Waring et al. (2017) for macro-moths or Sterling et al. (2012) for micro-moths (if the species was described). For micro-moth species not covered in Sterling & Parsons (2012), the average forewing length was taken from Manley (2021).

Habitat data was used to categorise species as 1 (habitat specialists) or 2 (habitat generalists). Species associated with two or less primary habitats were assigned to category 1 (specialist) and species associated with three or more primary habitats assigned to category 2 (generalist). Habitat information was gathered using the primary sources Waring et al. (2017) and Sterling et al. (2012), with additional habitat data taken from Emmet & Heath (1991) or UKMoths (www.ukmoths.org.uk). In a small number of cases, where habitat information was incomplete/out of date, habitat data was supplemented by expert opinion (M. Botham, 2022 pers comm).

Conservation status for macro-moths has been taken from Randle et al. (2019) and set as ‘Critically Endangered’, ‘Endangered’, ‘Vulnerable’, ‘Near threatened’ or ‘Regionally Extinct’. There is no equivalent comprehensive data of conservation status of micro-moths and so this trait was excluded in analysis of micro-moth species.

Table A3.4 below has detailed moth trait descriptions and source references.

Table A3.4 Moth trait definitions, groups and data source details. Continued on the next page.

Trait	Category	Category descriptions/definitions	Notes	Trait data sources
Mobility (forewing length in mm)	1	Very small (≤ 5 mm)	Derived from the average of the min and max forewing lengths.	Macro-moths: Waring et al. (2017) Micro-moths: Sterling et al. (2012) or Manley (2021) if not covered in Sterling.
	2	Small (5.1 - 10 mm)		
	3	Medium (10.1 - 20 mm)		
	4	Large (>20 mm)		
Larval host type - Woody	1	Larval food plant – woody (shrubs, coniferous or deciduous trees)	A small number of moth species occur in more than one category of larval food preference due to their dependence on more than one host type. Therefore, some species are included in more than one grouping within this trait.	Macro-moths: Waring et al. (2017) Micro-moths: 1° source - Sterling et al. (2012) 2° source - Emmet & Heath (1991) 3° source - UKMoths website (www.ukmoths.org.uk)
Larval host type - Forb	1	Larval food plant – forb (herbaceous plants, including aquatic plants)		
Larval host type - Grass	1	Larval food plant – grass (grasses, sedges, rushes)		
Larval host type - Other	1	Larval food plant – other (mosses, lichens/algae, fungi, animal matter, decaying plant matter, stored goods)		
Larval host specificity	1	Monophagous – feeds on a single host species		
	2	Oligophagous – feeds on several host species within the same family		
	3	Polyphagous – feeds on several hosts from different host types or different host species within the same type		
Voltinism	1	Univoltine – one distinct generation per calendar year		Macro-moths: Waring et al. (2017) Micro-moths: Emmet & Heath (1991)
	2	Mulitvoltine – all species showing any flexibility in voltinism beyond a single generation per calendar year	Understanding that some of these species may only produce one generation in cooler years and/or in higher altitudes and latitudes.	
Habitat type	1	Habitat specialist – associated with 1 or 2 primary habitat types	Habitat data was not available for a minority of species so these were excluded from analyses.	Macro-moths – Waring et al. (2017) Micro-moths – Sterling et al. (2012) * see footnote
	2	Habitat generalist – associated with 3 or more primary habitat types		

Trait	Category	Category descriptions/definitions	Notes	Trait data sources
Flight time	1	Adults first recorded in flight in April or earlier in year (early/spring flying species)	For multivoltine species this is based on the first appearance in the calendar year.	
	2	Adults first recorded in flight in May or later in year (late/summer flying species)		
Conservation status	1	Regionally Extinct	Micro-moth species were excluded, as there is no equivalent recent red list for micro-moths.	Randle et al. (2019)
	1	Critically Endangered (possibly extinct)		
	1	Critically Endangered		
	1	Endangered		
	1	Vulnerable		
	1	Near threatened		

*Where species habitat data was lacking in the primary sources (particularly for micro-moth species), information was gathered from Emmet & Heath (1991) or UKMoths (www.ukmoths.org.uk). In a minority of cases, where habitat information was incomplete/out of date, habitat data was supplemented by expert opinion (M. Botham, pers. comm., 2022)

A3.3 Bird species groups for analysis

Table A3.5 Bird species included in summer and winter analyses. Species only in summer are highlighted in red, those only in winter are highlighted in blue. Continued on the next page.

Species code	Species name	Species code	Species name
B.	Blackbird	MG	Magpie
BC	Blackcap	MH	Moorhen
BF	Bullfinch	ML	Merlin
BK	Black Grouse	MP	Meadow Pipit
BO	Barn Owl	MR	Marsh Harrier
BT	Blue Tit	MT	Marsh Tit
BZ	Buzzard	N.	Nightingale
C.	Carrion Crow	NH	Nuthatch
CB	Corn Bunting	OC	Oystercatcher
CC	Chiffchaff	P.	Grey Partridge
CD	Collared Dove	PE	Peregrine
CH	Chaffinch	PF	Pied Flycatcher
CK	Cuckoo	PW	Pied Wagtail
CR	Crossbill	R.	Robin
CT	Coal Tit	RB	Reed Bunting
CU	Curlew	RE	Redwing
CW	Cetti's Warbler	RG	Red Grouse
D.	Dunnock	RK	Redshank
DN	Dunlin	RN	Raven
FC	Firecrest	RO	Rook
FF	Fieldfare	RT	Redstart
G.	Green Woodpecker	RW	Reed Warbler
GC	Goldcrest	RZ	Ring Ouzel
GI	Goshawk	S.	Skylark
GH	Grasshopper Warbler	SB	Snow Bunting
GL	Grey Wagtail	SC	Stonechat
GO	Goldfinch	SD	Stock Dove
GP	Golden Plover	SE	Short-eared Owl
GR	Greenfinch	SF	Spotted Flycatcher
GS	Great Spotted Woodpecker	SG	Starling
GT	Great Tit	SH	Sparrowhawk
GW	Garden Warbler	SI	Swift
H.	Grey Heron	SK	Siskin
HF	Hawfinch	SL	Swallow
HH	Hen Harrier	SM	Sand Martin
HM	House Martin	SN	Snipe
HS	House Sparrow	ST	Song Thrush
HY	Hobby	TC	Treecreeper
J.	Jay	TD	Turtle Dove
JD	Jackdaw	TO	Tawny Owl
K.	Kestrel	TP	Tree Pipit
KF	Kingfisher	TS	Tree Sparrow
KT	Red Kite	W.	Wheatear
L.	Lapwing	WC	Whinchat
LE	Long-eared Owl	WH	Whitethroat
LI	Linnet	WK	Woodcock
LO	Little Owl	WP	Woodpigeon

Species code	Species name	Species code	Species name
LP	Little Ringed Plover	WR	Wren
LR	Lesser Redpoll	WT	Willow Tit
LT	Long-tailed Tit	WW	Willow Warbler
LW	Lesser Whitethroat	Y.	Yellowhammer
M.	Mistle Thrush	YW	Yellow Wagtail
MA	Mallard		

Table A3.6 Farmland Bird Indicator Species

Species code	Species name
CB	Corn Bunting
GO	Goldfinch
GR	Greenfinch
JD	Jackdaw
K.	Kestrel
L.	Lapwing
LI	Linnet
P.	Grey Partridge
RB	Reed Bunting
RO	Rook
S.	Skylark
SD	Stock Dove
SG	Starling
TD	Turtle Dove
TS	Tree Sparrow
WH	Whitethroat
WP	Woodpigeon
Y.	Yellowhammer
YW	Yellow Wagtail

Table A3.7 Summer invertebrate feeders

Species code	Species name	Species code	Species name
B.	Blackbird	MP	Meadow Pipit
BZ	Buzzard	OC	Oystercatcher
C.	Carrion Crow	P.	Grey Partridge
CB	Corn Bunting	PW	Pied Wagtail
CH	Chaffinch	RB	Reed Bunting
CU	Curlew	RK	Redshank
D.	Dunnock	RN	Raven
DN	Dunlin	RO	Rook
G.	Green Woodpecker	S.	Skylark
GH	Grasshopper Warbler	SC	Stonechat
GO	Goldfinch	SG	Starling
GP	Golden Plover	SN	Snipe
GR	Greenfinch	ST	Song Thrush
HS	House Sparrow	TP	Tree Pipit
JD	Jackdaw	TS	Tree Sparrow
KT	Red Kite	W.	Wheatear
L.	Lapwing	WC	Whinchat
LO	Little Owl	WH	Whitethroat
M.	Mistle Thrush	Y.	Yellowhammer
MG	Magpie	YW	Yellow Wagtail

Table A3.8 Winter invertebrate feeders

Species code	Species name	Species code	Species name
B.	Blackbird	MP	Meadow Pipit
BZ	Buzzard	OC	Oystercatcher
C.	Carrion Crow	PW	Pied Wagtail
CU	Curlew	R.	Robin
D.	Dunnock	RE	Redwing
FF	Fieldfare	RN	Raven
G.	Green Woodpecker	RO	Rook
GP	Golden Plover	RZ	Ring Ouzel
JD	Jackdaw	SC	Stonechat
KT	Red Kite	SG	Starling
L.	Lapwing	SN	Snipe
LO	Little Owl	ST	Song Thrush
M.	Mistle Thrush	W.	Wheatear
MG	Magpie		

Table A3.9 Summer seed eaters

Species code	Species name
GO	Goldfinch
GR	Greenfinch
LI	Linnet
S.	Skylark
SD	Stock Dove
TD	Turtle Dove
WP	Woodpigeon

Table A3.10 Winter seed eaters

Species code	Species name	Species code	Species name
BL	Brambling	MH	Moorhen
CB	Corn Bunting	MP	Meadow Pipit
CD	Collared Dove	P.	Grey Partridge
CH	Chaffinch	RB	Reed Bunting
D.	Dunnock	RG	Red Grouse
GO	Goldfinch	S.	Skylark
GR	Greenfinch	SD	Stock Dove
GT	Great Tit	TS	Tree Sparrow
HS	House Sparrow	WP	Woodpigeon
LI	Linnet	Y.	Yellowhammer
LR	Lesser Redpoll		

A3.4 Bat species data

Table A3.11 Summary information on the ecology for 16 bats species recorded during the survey. The table considers the potential to predict responses by bat species to AES habitats, based on their ecology.

Species	Distribution in England and habitat	Summary of recorded prey	Recorded foraging habits	Est. Core Sustenance Zone radius (km)	Theoretical likelihood of response to AES?	Refs
Common Pipistrelle *Pipistrellus pipistrellus*	Very abundant and widespread including farmland, woodland glades, tracks, wet meadows ponds, rivers, urban parks.	Broad: mosquitoes, midges, true flies, caddisflies, lacewings, mayflies.	Aerial: medium, low height.	2	Known response to farming practice (*)	BCT 2020
Soprano Pipistrelle *Pipistrellus pygmaeus*	Abundant and widespread; proportionally more numerous in river valleys/flood plains than Common Pipistrelle.	Broad, particularly knats, midges (Chironomidae, Ceratopogonidae).	Aerial: medium and low height.	3	Potentially insect or structural or riparian options.	BCT 2020
Noctule *Nyctalus noctula*	Common and widespread: open habitats, including forests, rivers and marshland, pasture.	Diptera, Lepidoptera and Coleoptera.	Aerial: high to medium height.	4	Potentially insect/ swards or wetland options?	BCT 2020
Leisler's Bat *Nyctalus leisleri*	Widespread but patchy, uncommon: Open habitats, rivers or lakes, pastures.	Moths, Trichoptera, Diptera, Coleoptera.	Aerial: high to medium height.	3	Potentially pasture options & structure	BCT 2020
Daubenton's Bat *Myotis daubentonii*	Common and widespread. Typically, rivers, lakes, ponds; maybe esp. where treelined.	Midges, caddisflies, mayflies	Aerial: low over water.	2	Potentially water body or linear options.	BCT 2020
Natterer's Bat *Myotis nattereri*	Widespread but patchy. Associated with trees and riparian woodland.	Midges, lacewings, beetles. centipedes, flies, spiders, caddis.	Aerial: low height and gleans.	4	Potentially structural options?	BCT 2020
Whiskered/Brandt's Bats *Myotis mystacinus/brandtii*	Widespread. Woodland edge; also, by water.	True flies, inc., horseflies	Aerial: medium height near vegetation.	2	Potentially wet structural options?	BCT 2020
Barbastelle Bat *Barbastella barbastellus*	Widespread, but uncommon and patchy, at low density. Deciduous woodland, wet meadows, water bodies, riparian strips.	Broad but principally Lepidoptera.	Aerial: High to low- at times at canopy level.	6	Potentially options helping moth abundance.	Sierro & Arlettaz 1997, Rydell et al., 1996

Species	**Distribution in England and habitat**	**Summary of recorded prey**	**Recorded foraging habits**	**Est. Core Sustenance Zone radius (km)**	**Theoretical likelihood of response to AES?**	**Refs**
Brown Long-eared Bat *Plecotus auritus*	Common and widespread: broadleaved trees, glades, shrubs, structured habitats, eg. mature hedgerows.	Diptera, Lepidoptera, centipedes, spiders.	Gleans from foliage (& ground?)	3	Potentially foliage and structural options.	BCT 2020
Serotine *Eptesicus serotinus*	Southern half of England, seemingly at low density; pastures.	Beetles, moths, true flies, dung flies.	Aerial: low height.	4	Potentially, meadow & pasture options.	BCT 2020
Rarer bats						
Nathusis' Pipistrelle *Pipistrellus nathusii*	Widespread but at low density. Attraction to water bodies.	Flying and aquatic insects.	Aerial: high, medium.	3	Low likelihood for farmland AES.	BCT 2020
Lesser horseshoe Bat *Rhinolophus hipposideros*	Southern England, localised. Sheltered valleys, deciduous areas of high habitat diversity (Bontadina et al., 2002).	Small: flies, midges, moths, beetles, wasps, spiders.	Gleans/forages low (Motte & Libois 2002).	2	Potentially: pasture and woodland options.	BCT 2020
Greater Horseshoe Bat *Rhinolophus ferrumequinum*	South-west England, very localised. Open tree habitats, pasture, parkland, hillsides, by water, cattle, hedges, treelines.	Midges, mayflies, Lepidoptera and Coleoptera.	Low by foliage or edge.	3	Potentially: pasture options.	BCT 2020

A4 Statistical analyses of taxa responses

A4.1 Statistical methods across all taxa

To analyse responses to AES gradients, observations of mobile taxa were summarised in three ways: the number of unique species seen (species richness), the Shannon index summarising both species richness and evenness (diversity) and the total number of individuals seen (abundance). For the majority of analyses we aggregated data within each survey square in each survey year (2017, 2018, 2019 and 2021). We aggregated across survey rounds and across transect sections or traps within a square, because the main focus here was how AES interventions affected the overall community recorded.

Responses (e.g. butterfly species richness) were assessed in relation to three core predictors: the AES intervention score in the survey square (local AES), the AES intervention in the surrounding 3 × 3 km squares (landscape AES) and the interaction between local and landscape AES gradients. Local AES was measured as the AES intervention score in the focal 1km square calculated from field mapping data including supplements. Landscape AES was measured as the AES intervention score in the surrounding 3 × 3 km calculated from GIS intervention data (see main report Section 2.1).

We accounted for the fact that survey squares were nested within NCAs by including NCA as a random effect. We also added a second random effect level to account for repeated visits to the same survey squares. This term was not fitted in previous annual reports as we did not have sufficient replication to estimate it, so addition of this term represents quite a large change to the model structure. We accounted for year to year fluctuations by including a survey year fixed term. These terms comprise the core model structure applied across all taxa.

We can write the core model as:

Response ~ local AES + landscape AES + local AES * landscape AES + survey year + (1|NCA/square)

We expanded this core model structure differently for each taxonomic group, accounting for the different survey methods and critical drivers. For example, we know that temperature explains a large amount of variation in moth trap counts, so we always included temperature at trap collection when modelling moths. The terms added to each taxonomic group core model are shown in Table A.4.1.

Table A4. 1 Model terms added to the core model structure for each taxonomic group.

Taxonomic group	Model terms added to core structure
Butterflies	Number of successful survey rounds, shade temperature, percentage sunshine
Bumblebees (transects)	Number of successful survey rounds, shade temperature, percentage sunshine
All bees, bumblebees and solitary bees (pan traps)	Number of pan traps surveyed, shade temperature, percentage sunshine
Hoverflies	Number of pan traps surveyed, shade temperature, percentage sunshine
Moths, macro-moths, micro-moths	Number of moth traps surveyed, temperature at trap collection
Birds	Habitat diversity
Bats	Botanical richness, habitat diversity or Broad-leaved woodland (depending on bat species)

For taxa recorded in pan traps (bees and hoverflies) we did not have directly corresponding measures of weather variables (temperature and sunshine) so the average of the measures from the butterfly and bumblebee transect surveys was used.

We fitted models with different response distributions depending on the variable and taxonomic group assessed. For example, abundance variables were often overdispersed (where variance is greater than the mean) and we assumed these responses came from a negative binomial distribution. Richness responses often fitted a Poisson distribution (a distribution suitable for counts where variance is similar to the mean). Diversity responses were always analysed with a Gaussian distribution which is suitable for continuous variables. However, diversity responses often showed a skew towards high values and therefore transformations such as the square or exponential were sometimes used to remove this skew before analysis.

Responses which did not fit into one of these distributions (e.g. where the response was zero inflated, or counts were very low) were not modelled. Although we note that there are many distributions which are suitable for modelling these sorts of responses such as mixture models, we did not have time to apply them within this project.

With four years of survey there were 198 observations (combinations of survey square and year). For birds, one square in the Fens NCA was not surveyed in 2017, so there were 197 observations used in bird analyses. In addition to the main analyses of the full dataset across all six NCAs, we also conducted analyses excluding the two upland NCAs (Dartmoor and the Yorkshire Dales). The AES gradients were designed to be applicable to upland as well as lowland options, and were successfully applied to both lowland and upland NCAs. However, upland habitats differ strongly from lowland habitats in their scale (unenclosed parcels) and the types of habitat present. Due to this, it is possible that AES gradient effects might be different in lowland NCAs, compared to across the whole dataset. These lowland only analyses were conducted with 144 observations (143 for birds). We surveyed one square with very high levels of local AES in 2017. Over the course of the survey the levels of AES in this square reduced, but in the first three years it represented an outlier along the local AES gradient. To ensure this outlier square was not having undue influence on the models we repeated all models without this square to confirm the results were not sensitive to the outlier.

The key output from the models are the estimates of the three AES terms (local AES, landscape AES and the interaction term), and the associated error around these. Usually we would say that if these terms are significant at $P < 0.05$ then this would indicate evidence for a relationship between the response and the AES gradients. However, due to the large number of models produced in the project, there is a high chance that we would report significant results simply by chance (using a threshold of $P < 0.05$ we expect to report a significant result by change about once in every 20 models). Therefore, to be sure that we do not place excessive confidence on results that may be due to chance, we do not consider results as providing statistical support for an effect based on any strict threshold. As a general guide, however, we consider P-values of less than 0.01 as providing strong or good evidence for a relationship, and values of < 0.05 providing weak evidence of possible relationships (Muff et al., 2022).

It is important to note that an effect of current AES management cannot be directly inferred from our results due to the potential for confounding historical or locational effects which we cannot account for in these spatial analyses. Inferring an impact of current AES will require the ability to look at change over time, which will only be possible after multiple years of survey or a potential resurvey after a break.

A4.2 Invertebrate specific analytical methods

A.4.2.1 Habitat models

For each headline response variable we tested whether responses were related to a selection of habitat variables considered to be important for each group. Although we have already demonstrated that habitat variables are independent of AES gradients and we did not set up the squares to look for habitat effects, it is possible that we may still have captured some relationships of interest. The set of habitat variables considered varied between invertebrate groups, and were prioritised based on evaluations of previous literature (Staley et al., 2016, Table A4.2).

Habitat variables were derived from field mapped habitat data for areal variables and from the OS VectorMap Local and OS/RPA Woody Linear Features (length of water and woody linear features respectively). Habitat diversity was calculated with the Shannon index, based on the proportions of each habitat recorded within the 1 km square. Squares with more habitat types or more even distribution of habitat had higher diversity scores. Mass flowering crops recorded by surveyors included beans, borage, broad beans, field beans, gladioli, kale, linseed, lucerne, oilseed rape, peas, potatoes, pumpkins, spring beans, sugar beet and sunflowers. Semi-natural land was defined as the area of bog, broadleaved woodland, calcareous grassland, coniferous woodland, fen, freshwater, heathland, inland rock, semi-improved grassland, acid grassland and neutral grassland plus cover of secondary habitats deciduous scrub and unmanaged herbaceous vegetation.

We considered covariance between habitat variables when including them in models. Some habitat components (e.g. area of arable and area of semi-natural habitat) were strongly correlated with each other either positively or negatively. Including both terms in the model would risk incorrect conclusions about which variable is important, so we excluded any pairs of variables with Pearson correlation coefficients of over 0.7 (Dormann et al., 2013). We found that correlations between certain habitat variables were much stronger when only the lowlands were included in the analysis. Therefore, when analysing habitat variables across lowland NCAs we used a smaller subset of habitat metrics.

On exploring the data we also decided to drop semi-natural habitat as a habitat covariate due to the strong confounding between NCA and semi-natural habitat areas. This arises as the areas of semi-natural are much larger in the two upland NCAs, therefore it is not possible to separate the effect of semi-natural habitat from NCA. In the lowlands semi-natural habitat is less confounded with NCA, but it is very strongly correlated with both habitat diversity and woodland area (both correlations = 0.78).

Table A4. 2 Habitat variables included in models, for each invertebrate taxonomic group.

Invertebrate group	**Habitat variables included in all NCA models**	**Habitat variables included in lowland NCA models**
Butterflies	Habitat diversity, woody linear feature length, water linear feature length, total woodland	Habitat diversity, water linear feature length
Bumblebees (transects)	Habitat diversity, woody linear feature length, water linear feature length, total woodland, area of mass flowering crops	Habitat diversity, water linear feature length, area of mass flowering crops
Wild bees, bumblebees and solitary bees (pan traps)	Habitat diversity, woody linear feature length, water linear feature length, total woodland, area of mass flowering crops	Habitat diversity, water linear feature length, area of mass flowering crops
Hoverflies	Habitat diversity, woody linear feature length, water linear feature length, total woodland, area of mass flowering crops, area of arable	Habitat diversity, water linear feature length, area of mass flowering crops
Moths	Habitat diversity, woody linear feature length, water linear feature length, total woodland	Habitat diversity, water linear feature length

We added the habitat terms from Table A4.2 to the core model structure defined in section A4.1. Because assessing relationships with habitat characteristics was a secondary aim of this work, these terms were not included in the models to assess the relationships with AES gradients to avoid reducing power to detect the AES effect. Adding habitat terms to the models did not change the inference around the AES effects for any insect responses.

A.4.2.2 Plant models

We expect many invertebrate taxa to respond strongly to the vegetation present in the survey squares as it will provide a range of resources including a direct source of food for many pollinators. Therefore we also considered whether invertebrates responded to the general vegetation properties of the square (e.g. plant richness) or the food resources provided by flowers.

Two survey components contributed to calculation of vegetation variables. Firstly, an annual botanical survey was conducted in two of the survey years, 2019 and 2021, comprised of 50 quadrats across each survey square (Section A1.8 above). We found that correlation between 2019 and 2021 surveys in terms of key vegetation metrics was very high and therefore we averaged botanical metrics between these two surveys for analysis. Secondly, a survey of floral resources was conducted on every transect section or pan trap visit (Section A1.2 above). We aggregated floral resources at square level by summing across transect sections, or traps, and rounds to capture total floral resources.

From the botanical surveys we calculated the percentage cover of graminoids, the total botanical richness and the Shannon diversity of plants recorded. From the floral resources surveys we used an index of floral resource provision to calculate a floral resource abundance index. The abundance of flowers was recorded in the field using one of two different protocols, depending on whether the resources were related to transects or traps. For transects, the abundance of flowers was recorded in two quadrats the following classes: 1–5; 6–25; 26–200; 201–1000; 1001–4999 and 5000+ flower units (defined as a single flower or an umbel, spike or capitulum on multi-flowered stems). To calculate an abundance-related floral resources index, the mid-point of each category was used and summed across all flowering species recorded for each survey square. For floral resources related to pan traps floral abundance was recorded in the following way: absolute counts for lower numbers (e.g. 1-10), to nearest 5 between 10 and 50, to nearest 10 between 60 and 200, and to nearest 50 above 200. Again, abundance was summed across species, rounds and traps to produce a single metric per square per year. We also calculated the richness of species providing floral resources.

Total botanical richness and richness of species providing floral resources were highly correlated with other botanical metrics and so were not included in models. The three remaining metrics (percent graminoids, botanical diversity and floral resource abundance) were added to the core model structure defined in A4.1. This was a separate model to the habitat model described above as the covariates address different questions relating to invertebrate responses.

For taxa recorded in pan traps, we might expect both the floral resources immediately surrounding the pan traps, and the resources available in the wider square to influence the invertebrates observed. Relationships between pollinating insects surveyed in pan traps and floral resources in the immediate vicinity of the trap are complex, and sometimes negative (O'Connor et al., 2018). We might expect floral resource abundance across the wider 1km square to have a positive relationship with pollinating insect abundance in pan traps, though this has not been widely assessed. Therefore, for these taxa we included both the pan trap floral resource abundance metric and the transect floral resource abundance metric in the models. These metrics were not strongly correlated with each other.

We assessed Pearson correlations between percent graminoids, botanical diversity and floral resources calculated on both transects and pan traps and the local and landscape AES gradients. Correlations were calculated across all NCAs, and for lowland NCAs only. All correlation coefficients were small, between -0.29 and 0.19, therefore at square level there was no evidence of strong associations between plant variables and the AES gradient scores. Adding plant terms to the models did not change the inference around the AES effects for any responses.

A4.2.3 Within square analysis

Although the main focus of this project was on assessing AES responses at the landscape scale, we also conducted limited analysis of whether responses varied in relation to the location of AES options within 1km survey squares. For richness, diversity and abundance of butterflies and bumblebees along transects we assessed whether responses differed depending on whether the transect section was on or off option. We did not filter by option type. Each insect transect section was categorised as either on or off option using the mapped option data (Section A1.7 above). The on / off option categories were attributed for each year of the field survey, as rotational options may change position each year, although for the majority of squares and transect sections the options were in place across all four years. We also scoped whether it would be possible to focus these within-square analyses on particular groups of options (e.g. those providing floral resources for pollinating insects) but replication was too low to allow the subdivision of the option data. Analyses thus consisted of a test of whether the insect response showed a relationship with whether the transect section was on or off AES option in that year of survey, regardless of the option identity. We aggregated response data across survey rounds for each transect section, so that responses indicate the total number of species or individuals seen on that transect section per year.

Due to the design of the survey, where transect sections were allocated to on and off AES areas roughly proportionally to the level of local AES, we did not include the local and landscape AES terms when analysing on and off AES differences. Therefore the differences represent the average difference between transect sections on and off AES across all levels of local and landscape AES. Because the survey was not designed specifically to look for within-square AES effects it was not possible to test whether the difference between on and off AES transects was conditional on the implementation of AES in the wider landscape.

The models used to assess transect section level differences in responses were similar to the models presented in A4.1, including a random effect structure that reflects nesting within NCAs, squares and survey years. We considered that the responses were likely to be influenced by the floral resources available on transect sections so we included both floral resource abundance and floral richness as covariates. Initial investigations showed that floral resources were on average slightly higher on AES transect sections (mean floral resource abundance of 7,049 on AES compared to 5,232 off AES). However, there was a huge amount of variation in resources (standard deviations 5,260 off AES and 6,943 on AES) meaning this relationship was not strong enough to preclude including this term alongside on/off AES in the models. We also included the percentage sunshine and shade temperature to account for climate effects. Transect sections varied in length which may influence the number of insects seen, so that was also included. We also included the number of rounds of survey per year as some transect sections did not have 4 full survey rounds. The full model was therefore:

Response ~ On/off AES + floral resources + floral richness + percent sunshine + temperature + transect length + no. rounds + (1|NCA/survey square/survey year)

A4.3 Bird specific analytical methods

In addition to effects of AES management, we examined associations between bird headline community responses and key habitat variables. Habitat variables were selected for inclusion in the full models if a significant effect was found when responses were modelled with the habitat variable, but without any AES effect. The habitat variables included when modelling all NCAs were habitat diversity, area of broadleaved woodland, and area of improved grassland. In lowland only analyses, the area of broadleaved woodland was not considered due to high correlation with habitat diversity (see A4.2.1 for further details on correlation calculations). Unlike for invertebrates, addition of habitat variables for birds did alter inference around AES effects, likely because habitat variables explained more of the variation in bird responses and accounting for this variation increased the ability to detect AES effects. Therefore habitat variables were added to all bird models in contrast to invertebrates.

Models for bird diet groups (see Section A3.3 above for details) followed the same structure as for the headline bird responses.

For single species bird analyses, we considered only the habitat diversity variable, since effects of both area of improved grassland and area of broadleaved woodland were in general non-significant when considered in species models without AES gradient effects. We therefore chose to standardise all single species models with the habitat diversity variable for consistency across species.

A4.4 Bats

A4.4.1 Acoustic identification of bats and validation

Passive real-time detectors are triggered when they detect sound within a certain frequency range and monitoring on this scale can generate a very large volume of recordings. Efficient processing of the recordings was greatly aided by a semi-automated approach for assigning recordings to species. In this study, we made use of an acoustic classifier TADARIDA (a Toolbox for Animal Detection in Acoustic Recordings Integrating Discriminant Analysis; Bas et al., 2017). This entailed extraction of 150 measures of call characteristics from each recording, and a comparison of these against those from an extensive reference library of manually identified ultrasound recordings. The classifier allows up to four different "identities" to be assigned to a single recording, according to probability distributions between detected and classified sound events. From these, species identities are assigned by the classifier, along with an estimated probability of correct classification (as compared with the underlying training database). Manual inspection of a sample of spectrograms using software SonoBat (http://sonobat.com) was used as an independent check of the original species identities assigned by the TADARIDA classifier. Here, TADARIDA identifications were assumed accurate where the estimated probability of correct classification was high (≥ 0.8). For most UK bat species, the identification classifiers are well developed (Newson et al., 2015) but signal quality can vary, so for conservative identification, high levels of stringency were applied, and data below the 0.5 threshold were discarded from the analyses. All those those above 0.5 were manually verified, except for the two most abundant pipistrelles, Common and Soprano, for which a sample of 1000 each were verified. Note, Whiskered/Brandt's Bats *Myotis mystacinus/brandtii* were treated as a species pair (herein termed, '*Myotis* spp.') due to them being currently inseparable by the detection method used.

A4.4.2 Units of measure for bat presence or activity and pre-analyses

In preparation for the analyses at species level, a basic dataset was compiled around three calculated units of 'activity' measure extracted from the validated raw data: 'presence/absence per night', 'bat presence per night sampled' and 'Max-pass' the maximum hourly pass rate per night', per bat species, per detector, per 1-km sample square. Max-pass was closely correlated to 'total passes per night' ($r^2 = 0.82$), and therefore consistent with similar analyses on bats using the same equipment (Newson et al., 2017a) but was chosen here to control for a variable number of hours of recording per night. Both presence/absence and max-pass accounted for variations in sampling effort caused by seasonal change or occasional battery failures. Bat activity, as a quantitative index of pass frequency (Hundt, 2012), had an unknown relationship to true abundance, in this study. The three units of activity measure at the species level, were tested analytically to identify the best model-fits and in the end only the presence/absence metric was carried forward into analytical model. Species richness was analysed under the same model structure. In practice for most analyses the max-rate metric failed to converge due to the data being heavily zero-inflated, so presence/absence which modelled successfully was used in all subsequent analyses and as such this approach is consistent with the 2017 pilot study conclusion found in section A2.4.

A4.4.3 Statistical analysis

All bat analyses were based on the same basic model structures below, constructed using the generalized linear mixed model procedure GLIMMIX (SAS Institute Inc. 2022).

The model structure was as follows:

- Square level model, data aggregated per year (as for other taxa):

Bat response variable = year+localAES+landscapeAES + localAES*landscapeAES + background habitat variables + random = NCA (square) / error term

- Square level model, data aggregated per survey night, repeated measures model:

Bat response variable = year+localAES+landscapeAES + localAES*landscapeAES + background habitat variables + random = NCA (sample night), subject=square / error term

AES gradient variables were standardised before adding to the models. For the presence/absence response variable a binomial error term was applied and for species richness a Poisson error term applied. Further model variants included one with an intra-square patch level measure added. The repeated measures expression above was used to test whether bat responses to AES provision might be more detectable at a higher replication rate, in this case by modelling bat presence at the per night level rather than at the per year level. Where habitat and plant variables were included in the bat models, they were calculated as described in Section A4.2.1 above, with the same thresholds for pairs of collinear variables.

A5 AES option implementation scoring

A5.1 Implementation scoring protocol details

Scoring protocols have been written to cover a suit of options with similar aims and objectives, the options incorporated into each protocol are listed in the final report (Tables 5.2.1 for upland unenclosed options and 5.3.1 – 5.3.2 for lowland and upland enclosed options). Additional option codes may have also been incorporated into protocols but no data from the field were available. Tables with the desirable and undesirable plant species used for scoring of each protocol are given in section A5.8.

A5.1.1 Arable plant

Options within this cluster are used to create opportunities for rare arable plants to germinate, flower, set seed and complete their life-cycle.

Table A5.1. 1 Attributes, criteria and implementation score for management for arable sown options producing habitats for rare arable plants.

Attribute	Criteria	Score
Boundary type	Woodland	2
	Hedgerow	2
	Grass strip	1
	Watercourse	1
	Fence	0
	None	0
	Other desirable	2
	Other undesirable	0
Bare ground	cover >10%	1
	cover <10%	0
Height of sward	at least 20% <= 10cm	1
	at least 20% > 10cm	0
Broadleaved weed cover	>20%	1
	<20%	0
Desirable plant species cover (1)	>10%	1
	<10%	0
Pernicious weed cover (2)	<20%	1
	>20%	0

A5.1.2 Arable floral resources

These are arable, cultivated options which should provide areas of flowering plants to boost essential food sources and habitat for beneficial pollinators and for other foraging invertebrates and birds. If successfully implemented there should be an abundant supply of pollen and nectar-rich flowers throughout the summer and pollinating insects such as bumblebees, solitary bees, butterflies and hoverflies using the flowers.

Table A5.1.1 Attributes, criteria and implementation score for management for arable sown options producing floral resources or habitats for beneficial insects, pollinators and birds.

Attribute	Criteria	Score
Aspect	W or NW aspect	2
	E, SE, S or SW aspect	1
	N or NE aspect	0
	Open field	0
Boundary type	Woodland	2
	Hedgerow	2
	Grass strip	1
	Watercourse	1
	Fence	0
	None	0
	Other desirable	2
	Other undesirable	0
Area of strip/block	0.25-0.5ha	1
	<0.25 or >0.5ha	0
Sown species (3)	at least 2	1
	<2	0
Cover of sown species	> 75%	1
	< 75%	0
Floral density	average no. of flowers/inflorescences per m^2	
	1-5	0
	6-10	1
	11-25	2
	26-50	3
	51-100	4
	101-250	5
	251-500	5
	500+	5
Richness of insect-pollinated plant species (Redhead et al., 2018)	average no. insect-poll plant species per m^2	
	<1	0
	1-2	1
	2.1-5	2
	5.1-10	3
	>10	4
Desirable plant species cover (1)	>10%	1
	<10%	0
Cutting	Evidence of appropriate cutting	1
	Evidence of inappropriate cutting	0
Compaction	There is **no** evidence of poaching/Compaction	1
	There is evidence of poaching/Compaction	0
	Buffer or grassed area has not been used as vehicle route or stock access	1

A5.1.3 Resource protection

These are options that cover a strip or area of land and maintain it in permanent vegetation so as to protect existing features including hedgerows, trees and archaeology, as well as water bodies. They can develop into valuable wildlife habitats in their own right and can contribute to the mosaic and connectivity of habitats in the wider landscape.

Table A5.1. 2 Attributes, criteria and implementation score for management for arable sown options producing resource protection or habitats for beneficial insects, pollinators and birds. Continued on the next page.

Attribute	**Criteria**	**Score**
	W or NW aspect	2
	E, SE, S or SW aspect	1
	N or NE aspect	0
	Open field	0
Boundary type	Woodland	2
	Hedgerow	2
	Grass strip	1
	Watercourse	1
	Fence	0
	None	0
	Other desirable	2
	Other undesirable	0
Area of strip/block	0.25-0.5ha	1
	<0.25 or >0.5ha	0
Sown species [3]	at least 2	1
	<2	0
Cover of sown species	> 75%	1
	< 75%	0
Floral density	average no. of flowers/inflorescences per m^2	
	1-5	0
	6-10	1
	11-25	2
	26-50	3
	51-100	4
	101-250	5
	251-500	5
	500+	5
Richness of insect-pollinated plant species (Redhead et al., 2018)	average no. insect-poll plant species per m^2	
	<1	0
	1-2	1
	2.1-5	2
	5.1-10	3
	>10	4
Desirable plant species cover [1]	>10%	1
	<10%	0
Cutting	Evidence of appropriate cutting	1
	Evidence of inappropriate cutting	0
Compaction	There is **no** evidence of poaching/Compaction	1

Attribute	Criteria	Score
	There is evidence of poaching/Compaction	0
	Buffer or grassed area has not been used as vehicle route or stock access	1
Fertiliser use	Fertilisers or manures have not been applied	1
	Fertilisers or manures have been applied	0
Pesticide use	Pesticides, including herbicides, appear only to have been used to spot-treat or weed-wipe for the control of injurious weeds, invasive non-natives, nettles or bracken	1
	Use of pesticides doesn't fit the above	0

A5.1.4 Hedgerow

Hedge management options and prescriptions are designed to increase the availability of blossom for invertebrates and will allow fruit and berries to ripen to provide food for overwintering birds. These options should improve the structure and longevity of hedgerows. If successful these options will deliver taller and wider hedges bearing blossom and berries, dense cover and an improvement to overall hedge condition (Gov.uk 2015).

Table A5.1. 3 Attributes, criteria and implementation score for management for hedgerow options.

Attribute	Criteria	Score
Size	=>2m in height and => than 1.5m wide	2
	<2m high and <1.5m wide	1
Gaps	>10%	1
	<10%	2
	Evidence of laying, coppicing or gapping up	3
Supplementary feeding	Signs of supplementary feeding of livestock within 2m of centre of hedge	0
	No signs of supplementary feeding of livestock within 2m of centre of hedge	1
Composition	>20% non-native shrubs*	0
	>80% native shrubs*	1
Floral density	average no. of flowers/inflorescences per m^2	
	1-5	0
	6-10	1
	11-25	2
	26-50	3
	51-100	4
	101-250	5
	251-500	5
	500+	5
Dead wood	Presence of deadwood or mature ivy growing on hedgerow trees	1
	Evidence that dead wood or ivy has been removed	0

A5.1.5 Winter bird food

These options aim to provide important food resources for farmland birds throughout the year, but especially in autumn and winter. If successful there will be an abundant and available supply of small seeds during the autumn and winter months and farmland birds eating the seeds from October and beneficial insects including bumblebees, solitary bees, butterflies and hoverflies using the flowers during the summer.

Table A5.1.4 Options and option descriptions which form part of the arable cultivated margins for bird food cluster

Attribute	Criteria	Score
Location	% of strip affected by overhanging trees <10%	1
	% of strip affected by overhanding trees >10%	0
Width and area	>=6m wide and >=0.4ha	1
	<6m or <0.4ha	0
Plant species cover	Desirable species >10%	1
	Desirable species <10%	0
	Sown species >70%	1
	Sown species <70%	0
Number of Sown species (4)	>=3 species from sown species list	1
	<3 species from sown species list	0
Number of Undesirable species (5)	No undesirable species recorded	1
	Presence of undesirable species (as per list, applies to all option code)	0
Flower production	>40% ground cover is of a sown plant that is flowering	1
	<40% ground cover is of a sown plant that is flowering	0
Seed production	Seed is available in winter	1
	Seed is not available in winter	0

A5.1.6 Grassland

Grassland - target feature: options under this cluster are aimed at maintaining or increasing the quantity of the targeted habitat, species or features. This may be carried out by increasing areas for nesting, hibernating or sheltering birds or insect pollinators.
Species rich grassland: These options are specifically designed to enhance and maintain existing or potential species rich grassland swards.
Grassland – wet. These options are used for maintaining or restoring wet grasslands that already or could provide suitable habitat for wintering populations of wildfowl and waders. They should look to creating a varied sward structure by the end of the growing season through grazing and/or cutting for hay with little or no winter grazing and poaching.

Table A5.1. 5 Attributes, criteria and implementation score for management of grassland options in lowland and enclosed upland areas.

Attribute	**Criteria**	**Score**
Bare ground *	cover 2-5%	1
	cover <2 or >5%	0
Height of sward *	at least 20% > 7cm	1
	at least 20% <= 7cm	1
	Average 5-15cm (Unless cut for hay?)	
Species composition	Cover of broadleaved herbs, sedges & rushes (excluding white clover, creeping buttercup & injurious weeds)	
	>30%	2
	10-30%	1
	<10%	0
	Cover of rye-grass & white clover	
	<10%	2
	11-30%	1
	>30%	0
Species richness	Number of grass, sedge, rush & broadleaved species	
	>15	3
	9-15	2
	4-8	1
	<4	0
Richness of insect-pollinated species (Redhead et al., 2018)	average no. insect-poll plant species per m^2	
	>10	4
	5.1-10	3
	2.1-5	2
	1-2	1
	<1	0
Floral density**	average no. of flowers/ inflorescences per m^2	
	<1	0
	1-10	1
	11-25	2
	26-50	3
	51-100	4
	>100	5
Grazing ***	Signs of supplementary feeding	
	No	1
	Yes	0
Fertilisation ***	Signs of manure or fertiliser	
	No	1
	Yes	0

***** Bare ground and sward height did not form part of the species rich grassland cluster protocol.
** Floral density did not form part of the scoring protocol for grassland for target features.

A5.1.7 Upland Habitat protocols for unenclosed options.

Table A5.1.7 Attributes, criteria and implementation score for management of upland unenclosed options on acid grassland

Attribute description	**Criteria**	**Score**
Forb cover	> 10 % should consist of forbs	3
	>=5% forb cover	2
	< 5% cover forbs	1
	< = 1%	0
Cover of non-native species	< =1%	2
	> 1% but <= 5%	1
	> 5%	0
Cover of bracken	< = 10%	2
	>10 but less than 20%	1
	> 20%	0
Cover of trees & scrub	< = 10%	2
	>10 but less than 20%	1
	> 20%	0
Cover weedy species (Bellis perennis and Ranunculus repens)	< = 25%	2
	>25 but < = 35%	1
	>35	0
Cover of undesirables [(6)]	< =1%	2
	>1 but <= 10%	1
	> 10%	0
Cover of Juncus effusus	< = 10%	2
	>10 but <= 20%	1
	>20	0
Cover of Bare ground	< = 10%	1
	> 10	0
Evidence of supplementary feeding	No	1
	Yes	0
Evidence of manure or fertiliser usage	No	1
	Yes	0
Average no. of flowers/ inflorescences per m^2	<1	0
	1-10	1
	11-25	2
	26-50	3
	51-100	4
	>100	5

Table A5.1.8 Attributes, criteria and implementation score for management of upland unenclosed options on bog.

Attribute	Criteria	Score
Presence of Indicator species (7)	At least 3 indicator species in at least 5 quadrats	3
	At least 2 indicator species in at least 5 quadrats	3
	At least 1 indicator species in at least 5 quadrats	1
	Less than 1 indicator species in at least 5 quadrats	0
Cover of undesirables (6)	<= 1%	2
	>1 but <= 10%	1
	>10% cover	0
Cover of grasses sedges and rushes	<=50%	2
	> 50 but <= 75	1
	> 75%	0
Scrub cover	< = 10%	2
	> 10 but <=20	1
	>20	0
Average sword height	<=50cm	3
Average sword height	>50cm	1
All sward height measurements are	> 50cm	0
Flowering frequency	Flowers present in at least 3 quadrats	2
	Flowers present in at least 2 quadrats but less than 3	1
	Flowers present in fewer than 2 quadrats	0
Average no. of flowers/ inflorescences per m^2	<1	0
	1-10	1
	11-25	2
	26-50	3
	51-100	4
	>100	5
Evidence of supplementary feeding	No	1
	Yes	0
Evidence of manure or fertiliser usage	No	1
	Yes	0

Table A5.1.9 Attributes, criteria and implementation score for management of upland unenclosed options on heath.

Attribute Description	Criteria	Score
Cover of indicator species [7]	>= 50	2
	>= 30 but <50	1
	<30	0
Undesirables [6]	< 1% cover	2
	> 1 < 10%	1
	>10 <25	0
Cover of DSH	>25%	3
	> 10 < 20%	2
	< 10% cover	1
Tree & scrub cover	< = 20%	3
	> 20% <30%	2
	>30%	0
Bracken cover	< = 10	2
	> 10 <20	1
	> 20	0
Frequency of dwarf shrub heath species	At least 2 in 5 or more quadrats	2
	At least 2 in 3 or more but less than 5 quadrats	1
	At least 2 in 1 or more but less than 3 quadrats	0
Bare ground cover	< = 10%	1
	> 10	0
Frequency of flowering	Flowers present in 3 quadrats	2
	Flowers present in 2 quadrats	1
	No flowering heathers present	0
Average no. of flowers/ inflorescences per m^2	<1	0
	1-10	1
	11-25	2
	26-50	3
	51-100	4
	>100	5
Evidence of supplementary feeding	No	1
	Yes	0
Evidence of manure or fertiliser usage	No	1
	Yes	0

A5.1.8 Lists of indicator species and deleterious species associated with option attribute scoring protocols above

(1)**Table A5.1.10** Desirable plant species, used in arable sown species scoring protocols, see Tables A5.1 – A5.3 above

Scientific name	**Common name**
Chenopodium album	Fat hen
Stellaria media	Chickweed,
Polygonum aviculare	Knotgrass
Polygonum persicaria	Redshank
Fallopia convolvulus	Black bindweed
Poa annua	Annual meadow-grass
Sinapis arvensis	Charlock
Persicaria lapathifolia	Curly top knotweed

(2) **Table A5.1.11** Pernicious weed species list, used in arable plant scoring protocol, see Table A5.1 above.

Scientific name	**Common name**
Cirsium arvense	Creeping thistle
Cirsium vulgare	Spear thistle
Rumex obtusifolius	Broad-leaved dock
Rumex crispus	Curled dock
Senecio jacobaea	Ragwort
Galium aparine	Cleavers
Urtica dioica	Nettle

[3] **Table A5.1.12** Desirable plant species list for arable floral and resource protection option clusters, Tables A5.1.2 and A5.1.3

Scientific name	**Common name**
Achillia millefolium	Yarrow
Agrostis capillaris	Common bent
Anthoxanthum odoratum	Sweet vernal grass
Brassica oleracea var. Sabellica	Kale
Camelina sativa	Gold of pleasure
Centaurea nigra	Black knapweed
Cynosurus cristatus	Crested dog’s-tail
Dactylis glomerata	Cocksfoot
Daucus carota	Wild carrot
Festuca ovina	Sheep’s fescue
Festuca rubra	Slender red fescue
Galium verum	Lady’s bedstraw
Leontodon hispidus	Rough hawkbit
Leucanthemum vulgare	Ox-eye daisy
Lolium perenne	Ryegrass
Lotus corniculatus	Bird’s-foot trefoil
Malva moschata	Musk mallow
Onobrychis viciifolia	Sainfoin
Phacelia tanacetifolia	Phacelia
Phleum bertolonii	Smaller cat’s-tail
Plantago lanceolata	Ribwort plantain
Poa pratensis	Smooth-stalked meadow grass
Prunella vulgaris	Self heal
Ranunculus acris	Meadow buttercup
Raphanus sativus var. Oleiformis	Fodder radish
Rhinanthus minor	Yellow rattle
Rumex acetosella	Sorrel
Trifolium hybridum	Alsike clover
Trifolium incarnatum	Crimson clover
Trifolium pratense	Red clover
Vicia sativa	Common vetch
	Winter barley
	Winter triticale

[4] **Table A5.1.13** Sown species list for winter bird food options, in scoring protocol Table A5.1.5

Scientific name	Common name
Beta vulgaris subsp. vulgaris	Beet
Brassica oleracea	Kale
Camelina sativa	Gold of Pleasure
Chenopodium quinoa	Quinoa
Cichorium intybus	Chicory
Echinochloa crus-galli	Cockspur grass
Fagopyrum esculentum	Buckwheat
Helianthus annuus	Sunflower
Hordeum distichon	Barley
Linum usitatissimum	Linseed
Panicum miliaceum	Millet
Phacelia tanacetifolia	Phacelia
Raphanus sativus	Fodder raddish
Sinapis alba	Mustard
x triticosecale	Triticale

[5] **Table A5.1.14** Additional undesirable plants for winter bird food plots, in scoring protocol Table A5.1.5

Scientific name	Common name
Cirsium arvense	Creeping thistle
Cirsium vulgare	Spear thistle
Cynara scolymus	Artichokes
Galium aparine	Cleavers
Melilotus altissimus	Sweet clover
Melilotus officinalis	Sweet clover
Phalaris canariensis	Canary grass
Rumex crispus	Curled dock
Rumex obtusifolius	Broad-leaved dock
Senecio jacobaea	Ragwort
Sorghum bicolor	Sorghum
Urtica dioica	Nettle
Vicia faba	Tick beans
Zea mays	Mays

[6] **Table A5.1.15** Undesirable species on upland options per broad habitat, for implementation scoring protocols in Tables A5.1.7 – A5.1.9.

Scientific name	**Broad habitat**
Arrhenatherum elatius	Acid grassland
Cirsium arvense	Acid grassland
Cirsium vulgare	Acid grassland
Cynosurus cristatus	Acid grassland
Rumex crispus	Acid grassland
Rumex obtusifolius	Acid grassland
Lolium perenne	Acid grassland
Senecio jacobaea	Acid grassland
Urtica dioica	Acid grassland
Rhododendron ponticum	Acid grassland
Ulex europaeus	Acid grassland
Arrhenantherum elatius	Bog
Cirsium arvense	Bog
Cirsium vulgare	Bog
Cynosurus cristatus	Bog
Rumex crispus	Bog
Rumex obtusifolius	Bog
Lolium perenne	Bog
Senecio jacobaea	Bog
Urtica dioica	Bog
Rhododendron ponticum	Bog
Ulex europaeus	Bog
Pteridium aquilinum	Heath
Cirsium arvense	Heath
Cirsium vulgare	Heath
Cynosurus cristatus	Heath
Rumex crispus	Heath
Rumex obtusifolius	Heath
Lolium perenne	Heath
Senecio jacobaea	Heath
Urtica dioica	Heath
Rhododendron ponticum	Heath
Ulex europaeus	Heath

[7] **Table A5.1.16** Indicator species on upland bog and heath habitats, used in implementation scoring protocols in Tables A5.1.8 and A5.1.9.

Scientific name	Broad habitat		Dwarf shrub heath species
Andromeda polifolia	Bog	Heath	
Arctostaphylos uva-ursi	Bog	Heath	
Betula nana	Bog	Heath	
Carex bigelowii	Bog		
Carex sp.		Heath	
Calluna vulgaris	Bog	Heath	DSH
Cornus suecica	Bog		
Empetrum nigrum	Bog	Heath	
Eriophorum angustifolium	Bog	Heath	
Eriophorum vaginatum	Bog	Heath	
Menyanthes trifoliata	Bog		
Myrica gale	Bog	Heath	
Narthecium ossifragum	Bog	Heath	
Rubus chamaemorus	Bog	Heath	
Rhynchospora alba	Bog	Heath	
Salix repens		Heath	
Sphagnum spp	Bog	Heath	
Trichophorum cespitosum	Bog	Heath	
Vaccinium spp.	Bog	Heath	DSH
Drosera spp.	Bog	Heath	
Ulex gallii			DSH
Erica spp.	Bog	Heath	DSH

A5.2 Differences in the implementation of individual attributes within option clusters

Looking within implementation scoring protocols at where variation occurred, or where scores were below the maximum, provides additional information about attributes within scoring clusters – i.e. those attributes that were generally well implemented and others that, for whatever reason, did not score highly. Reasons for poorer implementation will vary widely within and between options. These may also come not only from implementation of the option, but may also arise because of issues with surveying and verification as well as timing of surveys being carried out, or due to other factors such as soil type or microclimate. In addition, implementation of some options is known to be strongly affected by weather conditions (at time of establishment for arable sown options), and thus variable from one year to the next.

Implementation of different attributes for each option cluster varied widely. In general, management prescriptions as laid down in advice to landowners and farm managers have been implemented well or evidence for them not being implemented wasn't found e.g. inappropriate manure use, inappropriate supplementary feeding and placement of option. Attributes related to cover of certain indicator species or desirable species showed more variable implementation results across the surveyed sites. Further details for particular clusters are outlined below.

A5.2.1 Lowland option cluster and upland enclosed option attribute implementation

All attributes within the arable plant cluster generally had a high level of implementation, with the cover of desirable plants having lowest implementation performance (40%) across the attributes in this cluster (A5.2.3 Summary tables for attribute scores

Table A5.2.1 below).

Sown arable floristically enhanced margin options score well across most attributes (Table A5.2.2). However poorer levels of sown species cover were seen, with the majority of samples having less than 75% cover of sown species per m^2. It would appear that whilst the species are present (good scores for species richness of sown species) in these options, the cover of them across the margins is less than required. The poorer implemented result for desirable species for this particular option cluster is not necessarily a surprise for this suit of options. Desirable species in this circumstance are weedy species that provide cover for invertebrates and some seed for birds and whilst important, are less desirable than sown pollen and nectar species or perennial wildflowers in these particular options.

Attributes for resource protection margins scored consistently well >30% across all attributes (Table A5.2.3), evidence that prescription criteria for cutting regimes were not being met did not score as well as other attributes.

Whilst the number of sown species for bird food plots reaches implementation thresholds it would appear that their cover does not exceed 70%, with only 30% of surveyed wild bird food margins exceeding this value (Table A5.2.4). Only 13% of surveyed areas had over 40% of sown species flowering. Flowing times do differ between species however and only one visit to record flower numbers was made by surveyors (although protocols stated to do floral assessments at peak times this was not always possible with the range of species flowering and time restrictions). Also some winter bird food species need two years to produce seed e.g. kale and this was not taken into consideration in scoring although Broughton et al. (2020) also found that poor plant establishment and late flowering times a reason for poor delivery of seeds. Permitted species seed head counts were provided by BTO surveyors during December bird transects, a gradient threshold was looked into for this attribute but seed counts did not vary considerably between plots, the average number of permitted species seed heads was 23. Broughton et al. (2020) also found that winter bird food plots did not maintain seed through the winter to cover hunger gaps in March and already had low levels of seed availability at the beginning of winter.

Only two fields surveyed for species rich grassland (Table A5.2.5) had the highest score for species richness of grass, sedge, rush and broadleaved species (discounting injurious weeds) of over 15 species, with the majority of sites having 10-15 species. Grassland sites did not have a high floral density but as with other scoring protocols, whilst every effort was made to survey for floral resources at the peak of flowering this was sometimes difficult and therefore if a field had just been cut or was being grazed then floral diversity would be lower on these sites (but wasn't taken into consideration with the scoring methodology). This attribute is considered important for mobile taxa however and especially species richness of forbs is important for long term populations of pollinators in grassland environments (Woodcock et al., 2014, Hegland & Boeke 2006) and so has been retained within the scoring approach.

Management and attributes for bare ground and sward height showed high levels of implementation (100%) for both grassland for wading birds and grassland for target species (Tables A5.2.6 and A5.2.7).

Attributes within the hedgerow scoring all performed well (>70%) (Table A5.2.8). The attribute relating to the 'gappiness' of hedge was less well implemented across the sample size with 48% having gaps >10%. Different taxa will respond differently to structural components on hedge management and so this may not be an issue (Graham et al., 2018) but hedgerows will benefit wildlife if in good condition with a dense structure (Staley et al., 2015). This can be achieved through rejuvenation techniques, which reduce gappiness whilst enhancing invertebrate communities (Amy et al., 2015). There appears to be an indication that supplementary feeding within 2m of a hedge is occurring widely on the hedges surveyed.

A5.2.2 Upland unenclosed cluster attribute implementation

Acid grassland management options all were implemented well (100%), as were cover of undesirable species (82%). Floral diversity showed the most variable results but this is not unexpected within these upland environments (Table A5.2.9).

Heathland options also scored well for management prescription criteria e.g. manure or evidence of supplementary feeding (100%). Those attributes with less than 30% overall were numbers of undesirables (25%) (Table A5.2.10).

Implementation scores for upland bog habitats were most variable for those attributes related to flowering species frequency (13%) and density (25%), but also grass/sedge/rush cover (20%) and indicator species (40%) (Table A5.2.11). The score for management prescription criteria and number of undesirables had no variation with all areas surveyed meeting the higher implementation threshold criteria.

A5.2.3 Summary tables for attribute scores

Table A5.2.1 Summary data for attribute scores for arable options for arable plants. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.1

Attribute (simplified title)	Boundary type	Bare ground	Broad-leaved weed cover	Desirable species	Pernicious weeds
Number of samples	19	20	20	20	20
Total score for attribute	37	16	20	8	16
Max possible score	38	20	20	20	20
Attribute implementation performance	**97**	**80**	**100**	**40**	**80**

Table A5.2.2 Summary data for attribute scores for sown floral options. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.2

Attribute (simplified title)	Aspect	Cutting	Compaction	Boundary	Dimensions	Sown species presence	Sown species cover	Richness of insect pollinated plant species	Floral density	Desirable species cover
Number of samples	63	74	71	44	25	49	55	73	65	11
Total score for attribute	67	35	66	68	24	49	5	247	214	1
Max possible score	126	74	71	88	25	49	55	292	325	11
Attribute Implementation performance	**53**	**47**	**93**	**77**	**96**	**100**	**9**	**85**	**66**	**9**

Table A5.2.3 Summary data for attribute scores for options that mainly provide resource protection. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.3.

Attribute (simplified title)	Cutting	Compaction	No fertiliser	No pesticides	Dimensions	Richness of insect pollinated plant species	Floral density	Desirable species cover
Number of samples	112	79	83	86	42	107	105	14
Total score for attribute	34	51	56	60	41	347	225	8
Max possible score	112	79	83	86	42	428	525	14
Attribute implementation performance	**30**	**65**	**67**	**70**	**98**	**81**	**43**	**57**

Table A5.2.4 Summary data for attribute scores for winter bird food options. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.5.

Attribute (simplified title)	Over hanging trees	Dimensions	Desirable species cover	Sown species cover	Number of sown species	Undesirables	Flowering plants	Bird seed*
Number of samples	30	30	30	30	30	30	23	14
Total score for attribute	30	27	9	5	21	27	3	14
Max possible score	30	30	30	30	30	30	23	14
Attribute implementation performance	**100**	**90**	**30**	**17**	**70**	**90**	**13**	**100***

* Bird seed totals were collected by BTO surveyors during winter bird transects from options on transect routes only.

Table A5.2.5 Summary data for attribute scores for species rich grassland options. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.6.

Attribute (simplified title)	Manure	Supplementary feeding	Cover of broadleaved herbs, sedges & rushes	Cover of rye grass & white clover	Grass, sedge, rush & broadleaved species richness	Species richness insect pollinated plants	Floral density
Number of samples	25	25	30	30	30	30	23
Total score for attribute	22	23	45	40	55	77	65
Max possible score	25	25	60	60	90	120	115
Attribute implementation performance	**100**	**100**	**50**	**50**	**33**	**25**	**20**

Table A5.2.6 Summary data for attribute scores for grassland for target feature options. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.6.

Attribute (simplified title)	Manure	Supplementary feeding	Sward height	Bare ground	Cover of broadleaved herbs, sedges & rushes	Cover of rye grass & white clover	Grass, sedge, rush & broadleaved species richness
Number of samples	4	4	13	13	13	13	13
Total score for attribute	4	3	9	2	12	16	21
Max possible score	4	4	13	13	26	26	39
Attribute implementation performance	**100**	**100**	**100**	**100**	**50**	**50**	**33**

Table A5.2.7 Summary data for attribute scores for wet grassland for wading bird options. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.6.

Attribute (simplified title)	**Sward height**	**Bare ground**	**Cover of broadleaved herbs, sedges & rushes**	**Cover of rye grass & white clover**	**Grass, sedge, rush & broadleaved species richness**
Number of samples	5	5	5	5	5
Total score for attribute	3	1	8	8	6
Max possible score	5	5	10	10	15
Attribute implementation performance	100	100	50	50	33

Table A5.2.8 Summary data for attribute scores for hedgerow options. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.4.

Attribute (simplified title)	**Gaps**	**Timing recent cut**	**Supplementary feed**	**Composition Non native**	**Dead wood**	**Floral density**	**Dimensions**
Number of samples	63	59	50	50	50	51	50
Total score for attribute	98	118	13	49	36	178	83
Max possible score	189	118	50	50	50	255	100
Attribute implementation performance	**52**	**100**	**26**	**98**	**72**	**70**	**83**

Table A5.2.9 Summary data for attribute scores for acid grassland. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.7.

Attribute (simplified title)	**Evidence of manure usage**	**Evidence of supplementary feeding**	**Non-native species cover**	**% bracken cover**	**Trees/ scrub cover**	**Bare ground**	**Weedy species cover**	**Forbs cover**	**Undesirables cover**	***Juncus effuses* cover**	**Floral diversity**
Number of samples	17	17	15	17	17	17	17	17	17	17	15
Total score for attribute	16	16	30	24	34	17	34	43	28	31	23
Max possible score	17	17	30	34	34	17	34	51	34	34	75
Attribute implementation performance	**94**	**94**	**100**	**71**	**100**	**100**	**100**	**84**	**82**	**91**	**31**

Table A5.2.10 Summary data for attribute scores for heathland. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.7.

Attribute (simplified title)	**Evidence of manure usage**	**Evidence of supplementary feeding**	**% bracken cover**	**Trees / scrub cover**	**Bare ground**	**Undesirables cover**	**Floral diversity**	**Flower frequency**	**Indicator species cover**	**Dwarf shrub heath cover**
Number of samples	6	6	6	6	6	6	6	6	6	6
Total score for attribute	6	6	6	7	5	3	29	6	5	15
Max possible score	6	6	12	12	6	12	30	12	12	18
Attribute implementation performance	**100**	**100**	**50**	**58**	**83**	**25**	**97**	**50**	**42**	**83**

Table A5.2.11 Summary data for attribute scores for upland bog. For more detailed explanation of attributes and score threshold see detailed protocol in Appendix A5.1.7.

Attribute (simplified title)	**Evidence of manure usage**	**Evidence of supplementary feeding**	**Scrub cover**	**Grass / sedge / rush cover**	**Undesirables cover**	**Floral diversity**	**Flower frequency**	**Indicator species cover**
Number of samples	10	10	10	10	10	8	8	10
Total score for attribute	10	10	20	4	20	10	2	12
Max possible score	10	10	20	20	20	40	16	30
Attribute Implementation performance	**100**	**100**	**100**	**20**	**100**	**25**	**13**	**40**

A5.2.3 AES option implementation of attributes summary

Implementation scores across the survey generally show a good quality of management by landowners of options on the ground. Implementation weighted gradient scores at the 1km square level were consistent and closely related to previously calculated gradients (see main report Section 4.3.4).

Looking across implementation attributes and how they scored shows a positive delivery of option management but that some response variables associated e.g. cover of indicator species and cover of specific plant compositions are not at the levels for higher quality condition. This is consistent with findings from other AES monitoring projects which found that whilst some indicators of improvement to plant communities over the duration of HLS agreements, change had not been great enough to meet condition criteria thresholds over those same timescales (Staley et al., 2018).

A6 Additional bat analyses

Bat specific additional analyses

In this additional analysis the bat occurrence data (presence) were analysed at the per night level of aggregation, as guided by the preliminary pilot analysis conclusion reached in section A2.4. This had the effect of increasing the sampling replication rate within survey squares. The results of this analysis and the important caveats associated with it are discussed below, with cross reference to the headline analysis carried out in the main report under Section 5.7. The model structure used for these additional analyses was the second model in Section A4.4.3 above, the repeated measures analysis.

A 6.1 Bat specific additional analyses – community level

With less aggregation of the data, i.e. testing species richness per night with data pooled across the two detectors, there was weak evidence for a positive relationship between AES gradients and bat species richness at the local scale, compared to a stronger relationship to the background habitat variable botanical richness (to be consistent with the headline square-level analysis; Table A6.1.1). However, there was weak evidence for a negative relationship with the landscape AES gradient when data from all six NCAs was analysed (though not for lowland NCAs only), and an interaction term both when all NCAs and lowland only NCAs were considered (Table A6.1.1). Overall, the bat community response to AES was detectable (across all 6 NCAs only, representing a back transformed percentage change in species richness of approximately 3% over the local AES range of 250 to 10000) but was weaker than other influences in the environment (i.e. the plant species richness).

Table A6.1.1. Bat species richness responses to AES score based on richness values pooled across two detectors per night across all six NCAs and repeated for the four lowland NCAs only. Strong relationships with P<0.01 are highlighted in bold. AES scores were centred and standardised.

Species richness: repeated measures	All six NCAs			Lowland NCAs only		
	Sign	**Est**	***P***	**Sign**	**Est**	***P***
Local AES score	+	**0.036**	**0.001**	+	0.02	0.11
Landscape AES score	-	0.041	0.02	-	0.008	0.81
Local*landscape score	**-**	**0.099**	**<0.001**	**-**	**<0.096**	**<0.0001**
Botanical richness	+	**0.005**	**<0.0001**	+	**0.004**	**<0.0001**

A6.2 Bat specific additional analyses – species level

In Table A6.2.1, at the species level, there is stronger evidence for a response to AES when testing presence-absence at the per night level of replication (and with data aggregated across both detectors per square). When controlling for generally strong background habitat effects, there was evidence for a shallow but significant response to AES gradients at the landscape spatial scale for Barbastelle, Daubenton's Bat, Whiskered/Brandt's Bat pair, and Natterer's Bat, and for Noctule and Leisler's Bat at the local scale. In the lowland only NCAs the pattern was the repeated but with additional effects detected for Noctule and Leisler's Bat for the landscape AES gradient. Most of the significant responses to AES gradients were positive, but some were negative (Leisler's Bat and the landscape AES) and for the interaction effects, the direction of the relationship was especially inconsistent between species.

Table A6.2.1 Species level GLIMMIX output for a presence/absence response to AES scores at two scales (local and landscape), using presences per night (repeated measures model). The full dataset includes all six NCAs (for Barbastelle and Serotine, the five within-range NCAs). Appropriate background variables were selected for each species' model (consistent with the square-level headline analysis) according to a preliminary analysis. For the background variables, the probability values are summarised (*=*P*<0.05, ***P*<0.02, ****P*<0.001).

	(a) All six NCAs						
Bat species	**Local AES gradient score**		**Landscape AES gradient score**		**Local AES*Landscape interaction**		**Background habitat variables**
	Est	*P*	Est	*P*	Est	*P*	
Barbastelle	-0.02	<0.22	**0.49**	**0.0001**	-0.13	<0.02	Hab-div Bot-rich***
Daubenton's	-0.08	0.72	**0.18**	**0.001**	-0.014	0.75	Hab-div*** Bot-rich*** (Waterlinear)
Whiskered/Brandt's	-0.02	0.56	**0.096**	**0.001**	-0.056	0.55	Hab-div*** Woodylinear
Natterer's	-0.014	0.72	**0.24**	**0.0001**	0.001	0.23	Hab-div***
Leisler's	**0.17**	**0.001**	-0.61	0.02	-0.32	0.01	Hab-div***
Noctule	**0.13**	**0.007**	0.07	0.06	-0.12	0.04	Bot-rich***
Serotine	No convergence						
Common Pipistrelle	-0.03	0.93	-0.003	0.47	-0.01	0.16	Blwood Woody-liner***
Soprano Pipistrelle	0.04	0.32	-0.07	0.04	-0.02	0.54	Bot-rich***
Brown Long-eared	0.05	0.19	-0.06	0.11	-0.10	0.03	Hab-div*** Bot-rich*** Woodylinear***

Table A6.2.1 continued. Species level GLIMMIX output for a presence/absence response to AES scores at two scales (local and landscape), for the four lowland NCAs.

	(b) Four lowland NCAs						
Bat species	**Local AES gradient score**		**Landscape AES gradient score**		**Local AES*Landscape interaction term**		**Background habitat variables**
	Est	*P*	Est	*P*	Est	*P*	
Barbastelle	0.011	0.07	**0.35**	**0.0001**	**-<0.52**	**<0.0001**	Habdiv*** Bot-rich***
Daubenton's	**0.12**	**0.015**	**0.35**	**0.0001**	-0.14	0.04	Hab-div*** Bot-rich (Waterlinear)
Whiskered/ Brandt's	0.07	0.09	**0.23**	**0.0001**	-0.09	0.14	Hab-div*** Woodylinear*
Natterer's	0.02	0.67	**0.20**	**0.0003**	-0.001	0.97	Hab-div***
Leisler's	**0.20**	**0.0001**	**-0.45**	**0.001**	**-<0.34**	**0.001**	Hab-div***
Noctule	**0.12**	**0.007**	**0.16**	**0.0014**	-0.14	<0.02	Botrich***
Serotine	Did not converge						
Common Pipistrelle	0.04	0.47	0.09	0.88	-<0.07	0.34	Blwood Woodyliner
Soprano Pipistrelle	0.01	0.78	0.06	0.29	-<0.09	0.14	Hab-div*** Bot-rich
Brown Long-eared	0.06	0.15	0.009	0.86	-0.011	0.07	Hab-div*** Woodylinear***

A6.3 Discussion and caveats

Marginal effects on the presence of organisms are difficult to detect in complex ('noisy') circumstances, without a high level of independent sampling replication to increase analytical power. Within the constraints of the existing project framework and compared to report Section 7.7, there was opportunity to explore further by analysing bat responses aggregated per survey night rather than per year, while acknowledging important analytical caveats.

By analysing data per-night, this disaggregated the data to increase rate replication rate, but means that the data are likely to include considerable autocorrelation where bat activity is similar from night to night. For mobile foraging bats, this may not be as extreme as would be the case for breeding birds on territory, where the same individuals are present at that location throughout the season. For bats, this was accounted for here by using a formal repeated measures structure in models, but this may still have left pseudo-replication that then over-inflated the precision of parameter estimates. Potentially there is evidence here that a response to AES by some additional bat species to the headline analysis in the main report (found, as here, for Barbastelle and Daubenton's Bat but in addition for Natterer's Bats, Whiskered/Brandt's Bats and Noctule, with Leisler's Bat being inconsistent) may have been detectable at a higher level of sampling replication (that is, spatially as more survey squares).

A conservative conclusion from the main analysis of bat data, and the additional analysis described here, would be that there is evidence for positive relationships between bat richness and some species to AES gradients, but that there are stronger, clearer relationships with background habitats (again consistent with Froidevaux et al., 2019 especially for highly mobile species such as Barbastelle (this study) and Noctule (both studies)). Note also that where effects sizes were included for the AES gradient effects in the main report (Section 5.7), these effects were small. This is not surprising, since most farmed landscapes in England are heterogeneous in structure, with woodland, built areas and waterways, for example, influencing the presence of bats species (with other taxa) and with AES playing a contributory role. The presence, diversity and quantity of such features will determine the overall bat assemblage (and their foraging behaviours), with management from AES and other influences tending to provide revisions to the overall pattern. At the species level, the lack of response to AES provision by Common Pipistrelle could be an effect of analysing the presence/absence metric for this species because it was regularly present in all sample squares, so with low variation within the metric. Common Pipistrelle especially, and Soprano Pipistrelle too, may be species worth analysing further using activity data.

The form of the data for bats is different to the data for other taxa, in that activity is recorded, rather than counts of individuals. The pilot analyses found that presence/absence per night provided the most sensitive form of recorder data, as it avoided the high stochastic variability of raw activity records (see Appendix A2). The overall richness of bats considered only up to 16 species, with six of those being very rare in the data and one near-ubiquitous. Given the high mobility of bats and the intensive sampling that was conducted here, differences in detected richness per survey night, within an NCA, were inconsistent (positive at the local AES scale and negative at the landscape AES scale) and are likely to be driven by the occasional detection of rare species, a process that might effectively be random with respect to square location and management.

A7 Species lists per taxa

A7.1 Transect butterfly species list

Table A7.1 List of butterfly species recorded on transects, with the number of individuals recorded per species each year.

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Aglais io	Peacock	224	169	236	260
Aglais urticae	Small Tortoiseshell	843	630	696	1121
Anthocharis cardamines	Orange Tip	16	74	120	75
Aphantopus hyperantus	Ringlet	1468	1829	2451	1501
Argynnis paphia	Silver-washed Fritillary	6	6	13	4
Aricia agestis	Brown Argus	94	119	93	45
Boloria euphrosyne	Pearl-bordered Fritillary	0	1	0	0
Boloria euphrosyne/selene	Pearl-bordered/Spbd Fritillary	0	5	10	0
Boloria selene	Small Pearl-bordered Fritillary	0	11	0	6
Callophrys rubi	Green Hairstreak	0	33	62	24
Celastrina argiolus	Holly Blue	10	49	83	38
Coenonympha pamphilus	Small Heath	51	834	1346	906
Colias croceus	Clouded Yellow	2	6	2	1
Favonius quercus	Purple Hairstreak	0	10	3	1
Gonepteryx rhamni	Brimstone	25	19	51	60
Hipparchia semele	Grayling	0	2	1	1
Lasiommata megera	Wall Brown	1	18	7	3
Limenitis camilla	White Admiral	1	0	0	0
Lycaena phlaeas	Small Copper	43	81	70	49
Maniola jurtina	Meadow Brown	4296	4987	6945	6346
Melanargia galathea	Marbled White	31	103	247	198
Ochlodes sylvanus	Large Skipper	147	270	421	288
Other butterfly	Other butterfly	1	5	12	2
Pararge aegeria	Speckled Wood	147	245	128	143
Pieris brassicae	Large White	307	842	383	352
Pieris napi	Green-veined White	472	1293	1011	820
Pieris napi/rapae	Green-veined/Small White	0	307	125	80
Pieris rapae	Small White	994	3834	1848	1179
Polygonia c-album	Comma	92	77	50	46
Polyommatus icarus	Common Blue	324	465	160	89
Pyrgus malvae	Grizzled Skipper	0	0	3	0
Pyronia tithonus	Gatekeeper / Hedge Brown	1136	1098	1313	1203
Satyrium w-album	White-letter Hairstreak	0	1	0	2
Speyeria aglaja	Dark Green Fritillary	0	46	105	87
Thymelicus lineola	Essex Skipper	603	671	757	448

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Thymelicus lineola/sylvestris	Small/Essex Skipper	4	35	45	15
Thymelicus sylvestris	Small Skipper	96	100	196	271
Vanessa atalanta	Red Admiral	247	113	235	320
Vanessa cardui	Painted Lady	51	25	564	135

A7.2 Transect bumblebee species list

Table A7.2 List of bumblebee species recorded on transect surveys, with the number of individuals recorded per species each year.

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Bombus bohemicus	Gypsy Cuckoo Bee	0	0	4	11
Bombus campestris	Field Cuckoo Bee	0	2	0	0
Bombus hortorum	Garden Bumblebee	483	760	467	583
Bombus humilis	Brown-banded Carder Bee	0	0	0	3
Bombus hypnorum	Tree Bumblebee	127	173	257	125
Bombus jonellus	Heath Bumblebee	1	7	10	52
Bombus lapidarius	Red-tailed Bumblebee	4221	2190	1924	1951
Bombus lucorum	White-tailed Bumblebee	128	609	550	168
Bombus lucorum/terrestris agg.	White/Buff tailed Bumblebee	1515	405	388	1294
Bombus monticola	Bilberry Bumblebee	0	24	10	4
Bombus muscorum	Moss Carder Bee	1	4	0	0
Bombus pascuorum	Common Carder Bee	1834	1618	1928	2227
Bombus pratorum	Early Bumblebee	195	370	287	516
Bombus ruderarius	Red-shanked Carder Bee	1	2	0	0
Bombus ruderatus	Ruderal Bumblebee	113	125	70	125
Bombus rupestris	Red-tailed Cuckoo Bee	22	40	11	6
Bombus sylvestris	Forest Cuckoo Bee	4	5	10	6
Bombus terrestris	Buff-tailed Bumblebee	2219	749	2562	2166
Bombus vestalis	Vestal Cuckoo Bee	550	175	264	532
Bombus vestalis/bohemicus agg.		0	0	2	0
Group I - Browns		31	0	8	4
Group II Black-bodied red tails		1	0	3	0
Group III Banded red tails		1	0	1	2
Group IV Two-banded white tails		44	2	48	40
Group V Three-banded white tails		16	0	10	26
Other bumblebees		20	546	677	798
Other cuckoos		0	1	1	0

A7.3 Pan trap bee species list

Table A7.3 Species list of bees identified from pan traps, and the number of individuals recorded, in each year of survey.

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Andrena alfkenella	Alfken's Mining Bee	0	0	1	2
Andrena angustior	Groove-faced Mining Bee	0	80	80	93
Andrena barbilabris	Sandpit Mining Bee	0	0	0	1
Andrena bicolor	Gwyne's Mining Bee	35	52	57	27
Andrena bucephala	Big-headed Mining Bee	0	2	0	2
Andrena chrysosceles	Hawthorn Mining Bee	22	15	11	15
Andrena cineraria	Grey Mining Bee	6	19	25	11
Andrena clarkella	Clarke's Mining Bee	0	0	0	1
Andrena coitana	Small Flecked Mining Bee	0	0	1	0
Andrena dorsata	Short-fringed Mining Bee	14	14	9	3
Andrena flavipes	Yellow-legged Mining Bee	36	32	83	21
Andrena fucata	Painted Mining Bee	2	3	5	0
Andrena fulva	Tawny Mining Bee	0	3	2	0
Andrena fulvago	Hawksbread Mining Bee	2	3	3	3
Andrena fuscipes	Heather Mining Bee	0	3	0	0
Andrena haemorrhoa	Early Mining Bee	13	28	41	57
Andrena helvola	Coppice Mining Bee	1	6	6	2
Andrena humilis	Catsear Mining Bee	0	1	0	2
Andrena labialis	Large Meadow Mining Bee	0	1	1	1
Andrena labiata	Red-girdled Mining Bee	0	1	0	1
Andrena lapponica	Bilberry Mining Bee	0	8	11	4
Andrena minutula	Common Mini-mining Bee	72	82	125	67
Andrena nigriceps	Black-headed Mining Bee	0	1	0	0
Andrena nigroaenea	Buffish Mining Bee	5	22	16	22
Andrena nitida	Grey-patched Mining Bee	6	14	18	26
Andrena praecox	Small Sallow Mining Bee	0	2	2	0
Andrena scotica	Chocolate Mining Bee	0	9	3	1
Andrena semilaevis	Shiny-margined Mining Bee	1	12	10	0
Andrena subopaca	Impunctate Mini-mining Bee	3	18	27	6
Andrena synadelpha	Broad-margined Mining Bee	0	0	2	1
Andrena tarsata	Tormentil Mining Bee	0	1	1	0
Andrena trimmerana	Trimmer's Mining Bee	0	0	3	0
Andrena varians	Blackthorn Mining Bee	0	0	0	1
Andrena wilkella	Wilke's Mining Bee	0	1	1	1
Anthidium manicatum	Wool Carder Bee	0	0	1	1
Anthophora bimaculata	Hairy-footed Flower Bee	0	1	0	0
Anthophora furcata	Fork-tailed Flower Bee	0	0	1	0
Apis mellifera	Honeybee	295	177	285	277
Bombus barbutellus	Barbut's cuckoo-bee	7	5	12	10
Bombus bohemicus	Bohemian Cuckoo-bee	0	15	2	2

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Bombus campestris	Field Cucko-bee	1	0	0	3
Bombus cryptarum	Cryptic Bumblebee	0	27	1	6
Bombus hortorum	Garden Bumblebee	81	112	162	169
Bombus hortorum/ruderatus	Garden / Large Garden Bumblebee	0	0	1	0
Bombus hypnorum	Tree Bumblebee	17	8	14	14
Bombus jonellus	Heath Bumblebee	0	14	10	7
Bombus lapidarius	Red-tailed Bumblebee	105	65	84	59
Bombus lucorum	White-tailed Bumblebee	9	8	8	7
Bombus lucorum sensu lato		0	78	27	31
Bombus lucorum/terrestris	White-tailed / Buff-tailed Bumblebee	47	24	24	24
Bombus magnus	Northern Whtie-tailed Bumblebee	0	20	2	4
Bombus monticola	Bilberry Bumblebee	0	8	1	0
Bombus muscorum	Moss Carder Bee	0	14	1	0
Bombus pascuorum	Comon Carder bee	140	157	151	157
Bombus pratorum	Early Bumblebee	10	39	56	58
Bombus ruderatus	Large garden bumblebee	33	15	16	22
Bombus rupestris	Red-tailed Cuckoo Bee	4	3	1	0
Bombus sylvestris	Forest Cuckoo-bee	2	17	18	11
Bombus terrestris	Buff-tailed Bumblebee	145	50	218	143
Bombus vestalis	Vestal Cuckoo-bee	53	10	47	30
Chelostoma campanularum	Small Scissor Bee	3	0	12	10
Chelostoma florisomne	Large Scissor Bee	0	1	2	3
Coelioxys inermis	Shiny-vented Sharp-tail Bee	0	1	0	1
Colletes daviesanus	Davie's Colletes	1	2	0	0
Colletes succinctus	Heather Colletes	0	1	4	0
Dasypoda hirtipes	Pantaloon Bee	2	2	3	0
Halictus confusus	Southern Bronze Furrow Bee	0	2	0	0
Halictus rubicundus	Orange-legged Furrow Bee	20	45	46	12
Halictus tumulorum	Bronze Furrow Bee	215	213	167	86
Heriades truncorum	Large-headed Resin Bee	1	0	2	5
Hoplitis claviventris	Welted Lesser Mason-bee	0	0	2	1
Hylaeus brevicornis	Short-horned Yellow-face Bee	1	0	3	1
Hylaeus communis	Common Yellow-face Bee	38	18	32	31
Hylaeus confusus	White-jawed Yellow-face Bee	14	14	31	27
Hylaeus dilatatus	Chalk Yellow-face Bee	4	2	10	8
Hylaeus hyalinatus	Hairy Yellow-face Bee	3	4	0	9
Hylaeus pectoralis	Reed Yellow-face Bee	0	1	0	0
Lasioglossum albipes	Bloomed Furrow Bee	36	27	49	27
Lasioglossum calceatum	Common Furrow Bee	254	251	205	125
Lasioglossum cupromicans	Turquoise Furrow Bee	0	13	21	61
Lasioglossum fratellum	Smooth-faced Furrow Bee	0	55	50	41
Lasioglossum fulvicorne	Lime-loving Furrow Bee	14	7	7	7
Lasioglossum laevigatum	Black-mouthed Furrow Bee	5	4	13	11
Lasioglossum lativentre	Furry Claspered Furrow Bee	4	12	23	7

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Lasioglossum leucopus	White-fronted Green Furrow Bee	13	29	44	26
Lasioglossum leucozonium	White-zoned Furrow Bee	18	15	25	35
Lasioglossum malachurum	Sharp-collared Furrow Bee	209	155	622	313
Lasioglossum minutissimum	Least Furrow Bee	28	13	36	31
Lasioglossum morio	Comon Green Furrow Bee	63	66	47	34
Lasioglossum parvulum	Smooth-gastered Furrow Bee	2	3	3	6
Lasioglossum pauperatum	Squat Furrow Bee	2	6	11	18
Lasioglossum pauxillum	Lobe-spurred Furrow Bee	507	323	614	398
Lasioglossum punctatissimum	Long-faced Furrow Bee	0	4	3	0
Lasioglossum puncticolle	Ridge-cheeked Furrow Bee	8	6	15	21
Lasioglossum quadrinotatum	Four-spotted Furrow Bee	0	1	3	1
Lasioglossum rufitarse	Rufous-footed Furrow Bee	0	0	1	1
Lasioglossum smeathmanellum	Smeathman's Furrow Bee	7	12	8	17
Lasioglossum villosulum	Shaggy Furrow Bee	43	39	45	34
Lasioglossum xanthopus	Orange-footed Furrow Bee	0	0	1	1
Lasioglossum zonulum	Bull-headed Furrow Bee	49	96	59	20
Megachile centuncularis	Patchwork Leafcutter Bee	1	1	1	1
Megachile ligniseca	Wood-carving Leafcutter Bee	12	5	17	21
Megachile versicolor	Brown-footed Leafcutter Bee	0	0	0	7
Megachile willughbiella	Willugby's Leafcutter Bee	0	3	1	0
Melecta albifrons	Mourning Bee	0	0	0	2
Melitta haemorrhoidalis	Gold-tailed Melitta	1	0	1	0
Melitta leporina	Clover Melitta	0	1	1	2
Melitta tricincta	Red Bartsia Bee	2	3	0	1
Nomada conjungens	Fringeless Nomad Bee	0	0	0	1
Nomada fabriciana	Fabricus' Nomad Bee	1	4	4	8
Nomada ferruginata	Yellow-shouldered Nomad Bee	0	0	0	2
Nomada flava	Flavous Nomad Bee	3	3	7	5
Nomada flavoguttata	Small Nomad Bee	5	3	12	15
Nomada flavopicta	Blunthorn Nomad Bee	2	0	5	0
Nomada fucata	Nomada fucuta	3	1	3	4
Nomada glabella sensu Stockhert nec Thomson, 1870	Bilberry Nomad Bee	0	0	1	0
Nomada goodeniana	Gooden's Nomad Bee	4	4	5	7
Nomada lathburiana	Lathbury's Nomad Bee	0	1	1	2
Nomada marshamella	Marsham's Nomad Bee	0	2	1	2
Nomada panzeri	Panzer's Nomad Bee	0	0	2	0
Nomada ruficornis	Fork-jawed Nomad Bee	2	1	9	3
Nomada sheppardana	Sheppard's Nomad Bee	0	1	0	0
Osmia bicolor	Red-tailed Mason Bee	3	9	9	11
Osmia bicornis	Red Mason Bee	1	1	9	3
Osmia caerulescens	Blue Mason Bee	0	0	1	1
Osmia leaiana	Orange-vented Mason Bee	1	1	7	3

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Osmia spinulosa	Spined Mason Bee	26	3	23	26
Panurgus banksianus	Large Shaggy Bee	0	2	0	2
Sphecodes crassus	Swollen-thighed Blood Bee	1	0	0	0
Sphecodes ephippius	Bare-saddled Blood Bee	6	3	10	5
Sphecodes geoffrellus	Geoffrey's Blood Bee	1	1	2	0
Sphecodes gibbus	Dark-winged Blood Bee	0	0	1	0
Sphecodes hyalinatus	Furry-bellied Blood Bee	0	4	1	2
Sphecodes monilicornis	Box-headed Blood Bee	0	1	0	0
Sphecodes niger	Dark Blood Bee	1	1	0	0
Sphecodes puncticeps	Sickle-jawed Blood Bee	0	1	0	1
Sphecodes rubicundus	Red-tailed Blood Bee	0	0	1	0
Sphecodes scabricollis	Rough-backed Blood Bee	0	1	2	0
Stelis breviuscula	Little Dark Bee	0	0	1	0

A7.4 Pan trap hoverfly species lists

Table A7.4 List of hoverfly species identified from pan traps, with the number of individuals recorded per species in each year.

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Anasimyia contracta	Waisted Duckfly	1	2	1	3
Anasimyia lineata	Snouted Duckfly	0	1	0	0
Chalcosyrphus nemorum	Small Forest Hoverfly	3	9	4	3
Cheilosia albitarsis	Buttercup Blacklet	0	6	1	4
Cheilosia albitarsis sens.lat.		1	12	2	3
Cheilosia bergenstammi	Ragwort Blacklet	0	0	0	2
Cheilosia cynocephala	Musk Thistle Blacklet	0	1	0	0
Cheilosia fraterna	Orange Shinned Blacklet	0	21	31	9
Cheilosia illustrata	Bumblebee Blacklet	2	0	0	0
Cheilosia impressa	Burdock Blacklet	0	0	1	1
Cheilosia latifrons	Small Hawkbit Blacklet	0	5	1	11
Cheilosia pagana	Parsely Blacklet	3	4	1	5
Cheilosia proxima	Dull-bellied Blacklet	0	1	0	3
Cheilosia vernalis	Yarrow Cheilosia	0	2	0	3
Cheilosia vulpina	Stocky Blacklet	0	0	0	1
Chrysogaster solstitialis	Dark-winged Chrysogaster	0	0	1	0
Chrysogaster virescens	Red-horned Chrysogaster	0	3	0	0
Chrysotoxum arcuatum	Northern Spearhorn	0	2	0	0
Chrysotoxum bicinctum	Two-banded Spearhorn	0	2	8	2
Chrysotoxum festivum	Hook-barred Spearhorn	4	0	0	3
Chrysotoxum verralli	Verrall's Spearhorn	6	2	10	5
Dasysyrphus albostriatus	Stripe-backed Fleckwing	2	2	5	3
Epistrophe diaphana	Pale-sided Epistrophe	0	1	0	0
Epistrophe grossulariae	Broad-banded Epistrophe	0	2	0	1
Episyrphus balteatus	Marmalade Hoverfly	705	514	863	406
Eristalinus sepulchralis	Small Spotty-eyed Dronefly	39	78	29	39
Eristalis abusiva	Levels Dronefly	2	0	1	4
Eristalis arbustorum	Bog Hoverfly	29	42	36	63
Eristalis horticola	Stripe-winged Dronefly	0	0	1	6
Eristalis intricaria	Furry Dronefly	0	0	0	1
Eristalis intricarius	Furry Dronefly	0	2	1	0
Eristalis nemorum	Stripe-faced Dronefly	3	9	2	3
Eristalis pertinax	Tapered Dronefly	6	23	19	17
Eristalis rupium	Blotch-winged Dronefly	0	1	0	3
Eristalis tenax	Common Dronefly	26	76	89	83
Eumerus funeralis	Lesser Bulb Fly	2	1	0	3
Eumerus ornatus	Woodland Bulb Fly	0	2	1	0
Eumerus strigatus	Rural Lesser Bulbfly	31	36	25	113
Eupeodes corollae	Migrant Filed Syrph	193	145	304	98
Eupeodes latifasciatus	Meadow Field Syrph	0	223	2	24

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Eupeodes luniger	Common Spotted Field Syrph	9	9	34	9
Ferdinandea cuprea	Common Copperback	45	43	46	56
Helophilus hybridus	Marsh Tiger Hoverfly	9	8	5	4
Helophilus pendulus	Tiger Hoverfly	21	66	21	174
Helophilus trivittatus	Large Tiger Hoverfly	3	1	4	4
Heringia pubescens	Dark Heringia	0	2	0	0
Heringia vitripennis	Light Heringia	0	0	1	1
Lejogaster metallina	Green Marsh Hoverfly	0	2	1	0
Melanogaster aerosa	Dark Melanogaster	0	0	0	1
Melanogaster hirtella	Common Marsh Hoverfly	1	37	19	43
Melanostoma certum		0	0	11	0
Melanostoma mellinum	Short Melanostona	102	216	361	219
Melanostoma scalare	Slender Melanostoma	6	10	8	7
Meliscaeva auricollis	Spotted Meliscaeva	4	0	4	1
Meliscaeva cinctella	Banded Meliscaeva	0	0	0	2
Merodon equestris	Narcissus Fly	5	10	14	4
Myathropa florea	Batman Hoverfly	7	13	14	21
Neoascia obliqua	Butterbur Clubtail	0	1	0	0
Neoascia podagrica	Smudge-veined Clubtail	37	46	11	28
Neoascia tenur	Bridged Clubtail	8	2	3	3
Orthonevra nobilis	Long-horned Orthonerva	0	0	0	2
Parhelophilus versicolor	Mini Tiger fly species	1	0	1	0
Pipiza noctiluca	Common Pipiza	0	0	0	3
Pipizella viduata	Root Aphid Hoverfly species	1	2	1	2
Pipizella virens	Root Aphid Hoverfly species	0	1	0	0
Platycheirus albimanus	Boxer Fly species	11	31	20	48
Platycheirus angustatus	Boxer Fly species	0	1	2	2
Platycheirus clypeatus	Boxer Fly species	0	0	0	3
Platycheirus granditarsus	Boxer Fly species	1	123	2	28
Platycheirus manicatus	Boxer Fly species	52	52	23	68
Platycheirus peltatus	Boxer Fly species	5	13	22	23
Platycheirus peltatus agg.	Boxer Fly species	0	1	0	0
Platycheirus ramsarensis	Boxer Fly species	0	1	1	0
Platycheirus scutatus	Boxer Fly species	0	2	4	2
Platycheirus scutatus sens. lat.	Boxer Fly species	1	8	4	0
Portevinia maculata	Ramsons Hoverfly	0	0	1	0
Rhingia campestris	Common Snout	12	65	8	31
Rhingia rostrata	Grey-backed Snout	0	3	2	5
Riponnensia splendens		1	0	1	2
Scaeva pyrastri	White-clubbed Glasswing	4	1	6	1
Scaeva selenitica	Yellow-clubbed Glasswing	0	0	0	1
Sericomyia lappona	White-barred Peat Hoverfly	0	3	1	0
Sericomyia silentis	Yellow-barred Peat Hoverfly	1	69	27	29
Sphaerophoria fatarum	Bog Twist-tail	0	1	1	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Sphaerophoria females indet.		0	14	8	6
Sphaerophoria interrupta	Interrupted Twist-tail	1	3	0	5
Sphaerophoria philanthus	Dark-footed Twist-tail	0	1	0	4
Sphaerophoria rueppellii	Rueppell's Twist-tail	0	0	0	2
Sphaerophoria scripta	Common Twist-tail	75	40	260	190
Sphaerophoria taeniata	Broad-banded Twist-tail	8	7	1	26
Sphegina elegans	Elegant Pufftail	0	0	0	1
Syritta pipiens	Compost Hoverfly	11	24	11	21
Syrphus ribesii	Humming Syrphus	21	46	517	69
Syrphus torvus	Hairy-eyed Syrphus	1	5	14	1
Syrphus vitripennis	Glass-winged Syrphus	18	6	22	15
Tropidia scita	Tooth-thighed Hoverfly	0	2	3	3
Volucella bombylans	Bumblebee Plumehorn	6	7	24	9
Volucella inanis	Wasp Plumehorn	0	0	0	3
Volucella inflata	Orange-belted Plumehorn	0	2	1	1
Volucella pellucens	Pied Plumehorn	0	0	2	1
Xanthogramma pedissequum	Superb Ant-hill Hoverfly	2	3	6	7
Xanthogramma stackelbergi	Stackelberg's Hoverfly	1	1	1	0
Xylota jakutorum	Spruce-stump Leafwalker	0	0	0	1
Xylota segnis	Orange-belted Leafwalker	2	71	26	36

A7.5 Moth species list

Table A7.5 List of moth species recorded from moth traps, with the number of individuals recorded per species in each year.

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Abraxas grossulariata	Magpie	4	9	15	13
Abrostola tripartita	Spectacle	6	9	9	8
Abrostola triplasia	Dark Spectacle	0	0	0	2
Acasis viretata	Yellow-barred Brindle	1	9	2	4
Acentria ephemerella	Water Veneer	308	1172	382	43
Acleris aspersana	Ginger Button	0	3	6	3
Acleris comariana	Strawberry Tortrix	1	0	0	0
Acleris forsskaleana	Maple Button	10	2	42	20
Acleris hastiana	Sallow Button	4	0	0	0
Acleris holmiana	White-triangle Button	1	0	0	1
Acleris kochiella	Elm Button	0	0	1	0
Acleris laterana	Dark-triangle Button	7	4	4	2
Acleris rhombana	Rhomboid Tortrix	1	1	0	0
Acleris schalleriana	Viburnum Button	1	0	0	0
Acleris variegana	Garden Rose Tortrix	4	3	3	0
Acompsia cinerella	Ash-coloured Sober	0	3	22	9
Acrobasis advenella	Grey Knot-horn	43	78	60	80
Acrobasis consociella	Broad-barred Knot-horn	4	0	8	0
Acrobasis repandana	Warted Knot-horn	2	0	4	1
Acrobasis suavella	Thicket Knot-horn	2	0	4	7
Acrobasis tumidana	Scarce Oak Knot-horn	0	0	0	1
Acrolepia autumnitella	Bittersweet Smudge	0	1	0	0
Acronicta aceris	Sycamore	1	1	0	0
Acronicta leporina	Miller	1	0	1	0
Acronicta psi	Grey Dagger	2	2	2	1
Acronicta rumicis	Knot Grass	7	19	15	29
Acronicta tridens	Dark Dagger	0	0	1	0
Adaina microdactyla	Hemp-agrimony Plume	0	0	0	2
Adela croesella	Small Barred Long-horn	0	0	1	1
Aethalura punctulata	Grey Birch	0	0	0	2
Aethes beatricella	Hemlock Yellow Conch	1	0	0	0
Aethes cnicana	Thistle Conch	0	0	6	3
Aethes cnicana/rubigana		0	0	0	1
Aethes francillana	Long-barred Yellow Conch	0	0	0	1
Aethes rubigana	Burdock Conch	2	1	13	0
Aethes smeathmanniana	Yarrow Conch	6	13	15	50
Agapeta hamana	Common Yellow Conch	973	339	1040	214
Agapeta zoegana	Knapweed Conch	11	18	52	27
Aglossa pinguinalis	Large Tabby	0	1	0	0
Agonopterix alstromeriana	Brown-spot Flat-body	7	4	8	4

Species	**Common name**	**Number of individuals recorded in**			
		2017	**2018**	**2019**	**2021**
Agonopterix arenella	Brindled Flat-body	7	14	10	5
Agonopterix bipunctosa	Twin-spot Flat-body	1	0	0	0
Agonopterix conterminella	Sallow Flat-body	0	0	0	2
Agonopterix heracliana	Common Flat-body	11	6	8	8
Agonopterix kaekeritziana	Straw Flat-body	0	7	5	0
Agonopterix liturosa	Large Purple Flat-body	3	4	0	8
Agonopterix nervosa	Dark-fringed Flat-body	0	0	4	5
Agonopterix propinquella	Black-spot Flat-body	0	0	0	1
Agonopterix purpurea	Small Purple Flat-body	4	2	0	2
Agonopterix rotundella	Rolling Carrot Flat-body	2	0	0	0
Agonopterix spp.		0	0	1	0
Agonopterix subpropinquella	Ruddy Flat-body	2	1	1	0
Agonopterix yeatiana	Coastal Flat-body	0	0	1	0
Agriphila geniculea	Elbow-stripe Grass-veneer	3	14	2	7
Agriphila inquinatella	Barred Grass-veneer	0	17	133	34
Agriphila selasella	Pale-streak Grass-veneer	3	3	27	21
Agriphila straminella	Straw Grass-veneer	561	620	1914	260
Agriphila tristella	Common Grass-veneer	445	1540	1022	523
Agrotera nemoralis	Beautiful Pearl	0	0	1	0
Agrotis clavis	Heart and Club	24	18	16	5
Agrotis exclamationis	Heart and Dart	216	268	477	93
Agrotis ipsilon	Dark Sword-Grass	3	19	6	3
Agrotis puta	Shuttle Shaped Dart	18	55	41	32
Agrotis segetum	Turnip Moth	13	268	122	78
Alabonia geoffrella	Common Tubic	0	0	1	1
Alcis repandata	Mottled Beauty	128	120	42	55
Aleimma loeflingiana	Yellow Oak Button	19	37	3	8
Alucita hexadactyla	Twenty-plume Moth	0	0	3	0
Amphipoea crinanensis	Crinan Ear	0	45	8	8
Amphipoea fucosa	Saltern Ear	0	63	0	73
Amphipoea lucens	Large Ear	0	7	10	1
Amphipoea oculea	Ear Moth	2	9	8	11
Amphipyra berbera	Svensson's Copper Underwing	8	79	8	19
Amphipyra pyramidea	Copper Underwing	15	67	13	18
Amphipyra tragopoginis	Mouse Moth	56	39	108	27
Anacampsis blattariella	Birch Sober	0	0	1	0
Anacampsis populella	Poplar Sober	0	4	1	0
Anania coronata	Spotted Magpie	7	1	2	4
Anania crocealis	Ochreous Pearl	1	0	0	0
Anania fuscalis	Cinerous Pearl	0	1	0	1
Anania hortulata	Small Magpie	53	32	23	10
Anania lancealis	Long-winged Pearl	0	1	0	0
Anania perlucidalis	Fenland Pearl	14	9	2	3
Anarsia innoxiella	Acer Sober	0	0	1	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Anarsia spartiella	Small Crest	0	0	41	4
Anarta trifolii	Nutmeg	18	25	7	10
Ancylis achatana	Triangle-marked Roller	26	6	6	2
Ancylis badiana	Common Roller	10	1	5	6
Ancylis geminana	Festooned Roller	0	1	0	0
Ancylis myrtillana	Bilberry Roller	0	4	3	0
Ancylis unculana	Buckthorn Roller	0	0	1	0
Ancylosis oblitella	Saltmarsh Knot-horn	0	5	0	0
Angerona prunaria	Orange Moth	6	0	0	0
Anthophila fabriciana	Nettle-Tap	3	1	0	0
Antitype chi	Grey Chi	0	3	0	0
Apamea anceps	Large Nutmeg	6	80	82	135
Apamea crenata	Clouded-bordered Brindle	0	55	138	65
Apamea epomidion	Clouded Brindle	1	4	2	2
Apamea lithoxylaea	Light Arches	30	1	8	1
Apamea monoglypha	Dark Arches	383	98	1241	182
Apamea remissa	Dusky Brocade	2	103	284	56
Apamea scolopacina	Slender Brindle	0	0	2	0
Apamea sordens	Rustic Shoulder-knot	2	44	36	67
Apamea unanimis	Small Clouded Brindle	1	10	10	7
Aphelia paleana	Timothy Tortrix	1	2	9	0
Aphelia unitana	Northern Grey Twist	0	0	7	0
Aphomia sociella	Bee Moth	30	30	20	47
Aplocera plagiata	Treble-bar	0	1	5	3
Apoda limacodes	Festoon	8	1	1	5
Apodia bifractella	Dark Fleabane Neb	0	0	0	1
Apomyelois bistriatella	Heath Knot-horn	0	1	0	0
Apotomis turbidana	White-shouldered Marble	0	0	2	0
Aproaerema anthyllidella	Vetch Sober	1	9	38	7
Aproaerema cinctella	White-streak Sober	0	0	0	1
Aproaerema larseniella	White-strap Sober	4	0	0	1
Apterogenum ypsillon	Dingy Shears	3	0	0	0
Archanara dissoluta	Brown-Veined Wainscot	1	0	0	0
Archips podana	Large Fruit-tree Tortrix	16	6	2	1
Archips rosana	Rose Tortrix	1	0	1	0
Archips xylosteana	Variegated Golden Tortrix	7	11	0	9
Arctia caja	Garden Tiger Moth	7	0	11	1
Arctia villica	Cream-spot Tiger	0	1	0	1
Arenostola phragmitidis	Fen Wainscot	15	5	127	28
Argolamprotes micella	Bright Neb	0	0	0	1
Argyresthia albistria	Purple Argent	1	3	4	0
Argyresthia bonnetella	Hawthorn Argent	2	0	0	3
Argyresthia brockeella	Gold-ribbon Argent	1	0	2	0
Argyresthia conjugella	Apple-fruit Moth	0	0	1	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Argyresthia cupressella	Cypress-tip Moth	1	0	0	0
Argyresthia curvella	Brindled Argent	1	0	0	0
Argyresthia glaucinella	Oak-bark Argent	0	0	0	4
Argyresthia goedartella	Golden Argent	4	9	3	2
Argyresthia laevigatella	Larch-boring Argent	0	0	0	1
Argyresthia pruniella	Cherry-fruit Moth	0	3	0	2
Argyresthia semifusca	Brown Rowan Argent	1	2	0	0
Argyresthia semitestacella	Large Beech Argent	0	0	0	1
Argyresthia spinosella	Blackthorn Argent	2	3	4	4
Argyresthia spp.		5	2	1	0
Argyresthia trifasciata	Triple-barred Argent	0	0	0	2
Argyrotaenia ljungiana	Heather Twist	0	1	0	1
Aroga velocella	Dusky Groundling	0	1	3	0
Aspilapteryx tringipennella	Ribwort Slender	2	3	7	13
Asthena albulata	Small White Wave	2	1	8	3
Atethmia centrago	Centre-Barred Sallow	1	4	0	0
Athrips tetrapunctella	Northern Groundling	0	0	0	1
Autographa bractea	Gold Spangle	0	1	3	0
Autographa gamma	Silver Y	19	97	26	35
Autographa jota	Plain Golden Y	0	1	0	0
Autographa pulchrina	Beautiful Golden Y	1	4	14	0
Axylia putris	Flame	44	26	8	9
Bactra furfurana	Mottled Marble	23	474	39	45
Bactra lacteana	Scarce Sedge Marble	0	2	0	0
Bactra lancealana	Rush Marble	12	24	19	5
Batia lunaris	Lesser Tawny Tubic	1	0	23	0
Batrachedra praeangusta	Poplar Cosmet	3	3	2	0
Bedellia somnulentella	Bindweed Bent-wing	0	1	0	2
Biston betularia	Peppered Moth	2	19	10	4
Blastobasis adustella	Furness Dowd	176	244	387	307
Blastobasis lacticolella	Wakely's Dowd	45	13	34	30
Blastobasis maroccanella		0	0	0	2
Blastobasis vittata	Sussex Dowd	0	1	0	2
Blastodacna hellerella	Hawthorn Cosmet	13	1	11	1
Bohemannia quadrimaculella	Four-spot Pigmy	0	0	1	0
Borkhausenia fuscescens	Small Dingy Tubic	1	4	7	0
Brachmia blandella	Gorse Crest	13	0	18	5
Brachmia inornatella	Fen Crest	3	1	4	2
Brachylomia viminalis	Minor Shoulder-knot	1	0	1	0
Bryophila domestica	Marbled Beauty	0	0	1	0
Bryotropha affinis	Dark Groundling	1	1	1	2
Bryotropha basaltinella	Thatch Groundling	1	0	0	0
Bryotropha boreella	Mountain Groundling	0	0	1	2
Bryotropha domestica	House Groundling	0	0	2	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Bryotropha politella	Polished Groundling	0	3	24	16
Bryotropha senectella	Dull Red Groundling	6	10	21	12
Bryotropha similis	Obscure Groundling	0	0	11	0
Bryotropha spp.		0	2	0	0
Bryotropha terrella	Cinerous Groundling	62	93	284	107
Bucculatrix albedinella	Elm Bent-wing	0	0	1	0
Bucculatrix bechsteinella	Hawthorn Bent-wing	0	0	0	1
Bucculatrix cristatella	Crested Bent-wing	0	0	3	0
Bucculatrix nigricomella	Daisy Bent-wing	5	1	33	60
Bucculatrix ulmella	Oak Bent-wing	0	1	9	4
Bucculatrix ulmifoliae	Sapporo Elm Bent-wing	0	0	0	1
Bupalus piniaria	Bordered White	2	1	0	1
Cabera exanthemata	Common Wave	49	42	13	30
Cabera pusaria	Common White Wave	8	10	5	12
Calamotropha paludella	Bulrush Veneer	11	1	5	2
Calliteara pudibunda	Pale Tussock	0	16	9	21
Caloptilia cuculipennella	Feathered Slender	0	1	0	0
Caloptilia populetorum	Clouded Slender	0	1	0	0
Caloptilia robustella	New Oak Slender	0	0	4	5
Caloptilia semifascia	Maple Slender	1	0	3	0
Caloptilia stigmatella	White-triangle Slender	1	0	0	0
Calybites phasianipennella	Little Slender	5	2	8	2
Cameraria ohridella	Horse-Chestnut Leaf-miner	2	14	20	2
Campaea margaritaria	Light Emerald	16	33	36	36
Camptogramma bilineata	Yellow Shell	17	32	35	27
Caradrina clavipalpis	Pale Mottled Willow	3	17	7	4
Caradrina morpheus	Mottled Rustic	122	77	98	39
Carcina quercana	Long-horned Flat-body	6	5	6	2
Carpatolechia fugitivella	Elm Groundling	2	2	5	2
Caryocolum blandella	Short-barred Groundling	0	0	2	3
Caryocolum fraternella	Mouse-ear Groundling	3	15	23	8
Caryocolum tricolorella	Three-colour Groundling	0	1	0	0
Cataclysta lemnata	Small China-Mark	10	13	20	12
Catarhoe rubidata	Ruddy Carpet	0	2	1	0
Catocala nupta	Red Underwing	1	0	0	0
Catoptria falsella	Chequered Grass-veneer	8	9	20	7
Catoptria margaritella	Pearl-Band Grass Veneer	0	0	187	11
Catoptria pinella	Pearl Grass-veneer	0	0	1	4
Cedestis subfasciella	Brown Pine Ermel	0	2	0	0
Celaena haworthii	Haworth's Minor	0	99	21	12
Celaena leucostigma	Crescent	1	0	1	2
Celypha cespitana	Thyme Marble	1	0	0	0
Celypha lacunana	Common Marble	466	390	264	197
Celypha rivulana	Silver-striped Marble	0	1	10	5

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Celypha rosaceana	Roseate Marble	5	105	3	0
Celypha striana	Barred Marble	82	10	106	36
Ceramica pisi	Broom Moth	0	147	46	72
Cerapteryx graminis	Antler Moth	0	1883	1398	546
Cerastis rubricosa	Red Chestnut	0	0	2	0
Charanyca trigrammica	Treble Lines	10	108	565	381
Chiasmia clathrata	Latticed Heath	67	65	25	20
Chilo phragmitella	Reed Veneer	34	6	26	19
Chilodes maritima	Silky Wainscot	1	0	1	0
Chloroclysta siterata	Red-green Carpet	0	2	2	2
Chloroclystis v-ata	V-pug	71	1	3	2
Chrysoteuchia culmella	Garden Grass Veneer	4388	746	4853	1239
Cidaria fulvata	Barred Yellow	6	10	2	5
Cilix glaucata	Chinese Character	6	6	2	6
Clavigesta purdeyi	Pine Leaf-Mining Moth	3	0	0	0
Cleorodes lichenaria	Brussels Lace	2	0	2	2
Clepsis consimilana	Privet Twist	26	5	7	6
Clepsis spectrana	Cyclamen Tortrix	18	16	9	4
Clostera curtula	Chocolate-Tip	0	0	1	1
Cnephasia asseclana	Flax Tortrix	73	18	36	17
Cnephasia communana	May Shade	0	0	0	2
Cnephasia conspersana	Coast Shade	0	0	1	0
Cnephasia genitalana	Dover Shade	15	7	295	40
Cnephasia incertana	Light Grey Tortrix	18	11	9	8
Cnephasia longana	Long-winged Shade	60	4	323	23
Cnephasia pasiuana	Meadow Shade	174	1	369	62
Cnephasia pumicana	Cereal Tortrix	0	0	0	3
Cnephasia spp.		3	0	0	0
Cnephasia stephensiana	Grey Tortrix	153	2	37	26
Cochylichroa atricapitana	Black-headed Conch	19	48	49	36
Cochylidia heydeniana	Blue-fleabane Conch	0	0	1	1
Cochylidia implicitana	Chamomile Conch	1	1	0	0
Cochylimorpha straminea	Straw Conch	23	31	23	41
Coenobia rufa	Small Rufous	1	5	2	1
Coenotephria salicata	Striped Twin-Spot Carpet	0	34	36	31
Coleophora adspersella	Dusted Case-bearer	4	0	1	0
Coleophora albicosta	Gorse Case-bearer	0	15	11	29
Coleophora albitarsella	White-legged Case-bearer	1	0	1	1
Coleophora alcyonipennella	Clover Case-bearer	36	26	58	29
Coleophora alticolella	Common Rush Case-bearer	1	2	7	6
Coleophora amethystinella	Coast Green Case-bearer	0	0	1	2
Coleophora anatipennella	Pistol Case-Bearer	4	0	0	1
Coleophora argentula	Yarrow Case-bearer	0	1	0	0
Coleophora badiipennella	Pale Elm Case-bearer	1	0	2	0

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Coleophora caespititiella	Buff Rush Case-bearer	3	9	82	72
Coleophora clypeiferella	Body-marked Case-bearer	0	0	21	0
Coleophora conyzae	Spikenard Case-bearer	2	0	0	0
Coleophora coracipennella	Blackthorn Case-bearer	1	0	6	0
Coleophora deauratella	Red-clover Case-bearer	7	0	6	1
Coleophora discordella	Lotus Case-bearer	1	1	0	3
Coleophora flavipennella	Tipped Oak Case-bearer	5	4	3	3
Coleophora glaucicolella	Grey Rush Case-bearer	4	0	9	8
Coleophora hemerobiella	Black-stigma Case-bearer	0	0	1	2
Coleophora ibipennella	Forest Case-bearer	1	0	1	1
Coleophora laricella	Larch Case-bearer	0	0	1	22
Coleophora lassella	Toad-rush Case-bearer	0	0	6	3
Coleophora lineolea	Woundwort Case-bearer	0	0	1	4
Coleophora lusciniaepennella	Osier Case-bearer	1	1	0	0
Coleophora lutipennella	Common Oak Case-bearer	2	0	4	10
Coleophora mayrella	Meadow Case-bearer	6	4	13	2
Coleophora otidipennella	Wood-rush Case-bearer	0	0	0	4
Coleophora paripennella	Dark Thistle Case-bearer	0	0	3	1
Coleophora peribenanderi	Pale Thistle Case-bearer	9	6	16	24
Coleophora pyrrhulipennella	Ling Case-bearer	0	9	4	11
Coleophora salicorniae	Glasswort Case-bearer	0	0	1	0
Coleophora saxicolella	Orache Case-bearer	4	10	5	8
Coleophora serratella	Common Case-bearer	3	2	6	1
Coleophora siccifolia	Grey Birch Case-bearer	1	0	0	0
Coleophora spinella	Apple and Plum Case-bearer	5	0	3	0
Coleophora spp.		0	3	2	3
Coleophora sternipennella	Speckled Case-bearer	1	0	3	0
Coleophora striatipennella	Hedge Case-bearer	1	6	21	29
Coleophora taeniipennella	Small Rush Case-bearer	1	0	1	1
Coleophora tamesis	Jointed-rush Case-bearer	1	1	0	0
Coleophora therinella	Black-bindweed Case-bearer	4	1	0	0
Coleophora trifolii	Large Clover Case-Bearer	2	0	0	0
Coleophora trigeminella	Scarce Thorn Case-bearer	0	1	0	0
Coleophora versurella	Pale Orache Case-bearer	6	16	26	13
Coleophora vestianella	Eastern Case-bearer	1	0	0	1
Colocasia coryli	Nut-Tree Tussock	4	3	10	21
Colostygia olivata	Beech-Green Carpet	0	0	0	1
Colostygia pectinataria	Green Carpet	26	318	192	794
Comibaena bajularia	Blotched Emerald	0	1	0	0
Coptotriche marginea	Bordered Carl	0	4	2	1
Cosmia affinis	Lesser-spotted Pinion	1	3	3	2
Cosmia trapezina	Dun-bar	114	122	232	60
Cosmorhoe ocellata	Purple Bar	9	104	33	37
Crambus lathoniellus	Hook-streak Grass-veneer	16	245	369	365

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Crambus pascuella	Inlaid Grass-veneer	4	1	21	7
Crambus perlella	Satin Grass-veneer	391	51	213	88
Craniophora ligustri	Coronet	19	5	3	5
Crassa unitella	Golden-brown Tubic	40	10	340	26
Crocallis elinguaria	Scalloped Oak	39	22	70	37
Crombrugghia distans	Breckland Plume	0	0	1	0
Cryphia algae	Tree-Lichen Beauty	0	9	14	10
Cryptoblabes bistriga	Double-striped Knot-horn	1	0	0	0
Cybosia mesomella	Four-dotted Footman	1	4	7	51
Cyclophora albipunctata	Birch Mocha	0	3	0	0
Cyclophora annularia	Mocha	0	1	0	2
Cyclophora linearia	Clay Triple-Lines	1	1	0	3
Cyclophora punctaria	Maiden's Blush	3	12	5	3
Cydia amplana	Vagrant Piercer	0	1	0	0
Cydia fagiglandana	Large Beech Piercer	0	0	3	3
Cydia nigricana	Pea Moth	2	0	0	0
Cydia pomonella	Codling Moth	3	6	4	3
Cydia splendana	Marbled Piercer	10	12	39	15
Cydia ulicetana	Grey Gorse Piercer	0	13	15	5
Dasycera oliviella	Scarce Forest Tubic	0	1	0	0
Deilephila elpenor	Elephant Hawkmoth	9	6	18	5
Deilephila porcellus	Small Elephant Hawkmoth	0	4	9	6
Deileptenia ribeata	Satin Beauty	3	0	2	0
Deltote pygarga	Marbled White Spot	6	47	4	2
Deltote uncula	Silver Hook	0	0	1	0
Denisia similella	Northern Tubic	0	0	6	1
Denticucullus pygmina	Small Wainscot	4	2	45	14
Depressaria chaerophylli	Streaked Flat-body	0	1	0	1
Depressaria daucella	Dingy Flat-body	0	1	0	0
Depressaria douglasella	Carrot Flat-body	0	0	0	2
Depressaria pulcherrimella	Pignut Flat-body	0	3	1	4
Depressaria radiella	Parsnip Moth	4	7	0	0
Depressaria sordidatella	Chervil Flat-body	7	11	20	6
Diachrysia chrysitis	Burnished Brass	38	31	54	25
Diacrisia sannio	Clouded Buff	0	8	6	13
Diaphora mendica	Muslin Moth	0	28	4	3
Diarsia brunnea	Purple Clay	0	0	4	1
Diarsia mendica	Ingrailed Clay	4	13	139	39
Diarsia rubi	Small Square-spot	67	47	8	62
Dichrorampha acuminatana	Sharp-winged Drill	2	5	2	16
Dichrorampha aeratana	Obscure Drill	1	0	0	0
Dichrorampha alpinana	Broad-blotch Drill	1	0	0	1
Dichrorampha petiverella	Common Drill	0	1	0	0
Dichrorampha simpliciana	Round-winged Drill	4	10	10	6

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Dichrorampha vancouverana	Gold-fringed Drill	0	0	1	0
Dioryctria abietella	Dark Pine Knot-horn	0	1	0	0
Ditula angustiorana	Red-Barred Tortrix	6	0	13	0
Donacaula forficella	Pale Water-veneer	29	17	9	12
Drepana falcataria	Pebble Hook-tip	0	0	4	3
Drymonia dodonaea	Marbled Brown	0	1	4	1
Dypterygia scabriuscula	Bird's Wing	0	2	0	1
Dyscia fagaria	Grey Scalloped Bar	0	0	1	0
Dysstroma citrata	Dark Marbled Carpet	0	2	2	0
Dysstroma truncata	Common Marbled Carpet	1	33	8	16
Dystebenna stephensi	Oak Cosmet	0	0	2	0
Eana incanana	Bluebell Shade	3	1	8	1
Eana osseana	Dotted Shade	0	143	743	125
Eana penziana	Large Mottled Shade	0	0	0	3
Earias clorana	Cream-Bordered Green Pea	1	0	0	0
Ecliptopera silaceata	Small Phoenix	19	12	20	11
Ectoedemia albifasciella	White-banded Pigmy	0	1	0	2
Ectoedemia atricollis	Pinch-barred Pigmy	1	0	0	0
Ectoedemia heringella	New Holm-Oak Pigmy	0	0	0	1
Ectoedemia heringi	White-spot Pigmy	0	1	9	1
Ectoedemia louisella	Maple-seed Pigmy	0	1	0	0
Ectoedemia spp.		1	0	2	0
Ectoedemia subbimaculella	Spotted Black Pigmy	0	0	9	2
Ectropis crepuscularia	Engrailed	28	1	1	3
Eidophasia messingiella	Bitter-cress Smudge	2	0	0	1
Eilema complana	Scarce Footman	45	1	100	108
Eilema depressa	Buff Footman	5	0	18	1
Eilema griseola	Dingy Footman	204	50	391	310
Eilema lurideola	Common Footman	1104	6	830	245
Elachista adscitella	Oblique-barred Dwarf	0	0	1	1
Elachista albifrontella	White-headed Dwarf	0	1	0	0
Elachista apicipunctella	Pearled Dwarf	0	1	1	0
Elachista argentella	Swan-feather Dwarf	0	3	19	19
Elachista atricomella	Black-headed Dwarf	2	6	14	54
Elachista canapennella	Little Dwarf	30	10	71	114
Elachista consortella	Field Dwarf	1	5	40	8
Elachista freyerella	Broken-barred Dwarf	3	2	6	0
Elachista gangabella	Yellow-barred Dwarf	0	1	0	1
Elachista maculicerusella	Triple-spot Dwarf	16	5	53	31
Elachista obliquella	Wood Dwarf	0	0	1	1
Elachista spp.		0	2	3	1
Elachista stabilella	Southern Dwarf	0	3	11	11
Elachista subalbidella	Buff Dwarf	0	6	0	4
Elachista subocellea	Brown-barred Dwarf	1	0	1	0

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Elachista utonella	Bog Dwarf	0	0	1	0
Electrophaes corylata	Broken-Barred Carpet	0	2	0	1
Elophila nymphaeata	Brown China-Mark	14	15	4	11
Emmelina monodactyla	Common Plume	17	56	15	9
Endothenia ericetana	Heath Marble	2	5	11	0
Endothenia gentianaeana	Teasel Marble	0	4	3	0
Endothenia marginana	Bordered Marble	0	0	0	2
Endothenia nigricostana	Black-edged Marble	1	0	0	0
Endothenia quadrimaculana	Blotched Marble	17	14	28	2
Endothenia ustulana	Bugle Marble	0	0	1	0
Endotricha flammealis	Rosy Tabby	24	1	108	55
Endrosis sarcitrella	White-shouldered House-moth	11	16	11	8
Ennomos alniaria	Canary-Shouldered Thorn	2	4	1	5
Ennomos erosaria	September Thorn	1	0	0	0
Ennomos fuscantaria	Dusky Thorn	14	11	7	7
Ennomos quercinaria	August Thorn	0	0	0	2
Entephria flavicinctata	Yellow-ringed Carpet	0	0	2	0
Epermenia chaerophyllella	Garden Lance-wing	4	0	0	0
Epermenia falciformis	Large Lance-wing	0	0	2	0
Ephestia elutella	Cacao Moth	1	0	1	0
Ephestia woodiella	False Cacao Moth	3	3	2	11
Epiblema cirsiana	Knapweed Bell	1	1	0	0
Epiblema costipunctana	Ragwort Bell	0	0	2	0
Epiblema foenella	White-foot Bell	3	1	2	0
Epiblema grandaevana	Great Bell	2	0	1	0
Epiblema scutulana	Thistle Bell	0	6	18	1
Epinotia abbreviana	Brown Elm Bell	8	12	5	6
Epinotia caprana	Large Sallow Bell	0	1	0	0
Epinotia immundana	Common Birch Bell	0	0	1	0
Epinotia nanana	Small Spruce Bell	0	0	2	0
Epinotia nisella	Grey Poplar Bell	2	7	2	3
Epinotia signatana	Black-brindled Bell	4	2	1	0
Epinotia tenerana	Nut-bud Moth	3	0	0	2
Epione repandaria	Bordered Beauty	8	5	0	6
Epiphyas postvittana	Light Brown Apple Moth	6	6	0	4
Epirrhoe alternata	Common Carpet	86	224	175	137
Epirrhoe galiata	Galium Carpet	0	43	26	28
Epirrhoe rivata	Wood Carpet	8	4	0	0
Epirrhoe tristata	Small Argent & Sable	0	1	0	0
Eremobia ochroleuca	Dusky Sallow	58	7	199	204
Esperia sulphurella	Sulphur Tubic	0	0	0	2
Etainia decentella	Sycamore-seed Pigmy	0	0	1	2
Ethmia quadrillella	Comfrey Ermel	0	3	0	0
Euchoeca nebulata	Dingy Shell	1	1	1	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Eucosma campoliliana	Marbled Bell	3	2	3	0
Eucosma cana	Hoary Belle	267	48	88	29
Eucosma conterminana	Pale Lettuce Bell	0	0	4	4
Eucosma hohenwartiana	Bright Bell	69	4	54	30
Eucosma metzneriana	Mugwort Bell	0	0	1	0
Eucosma obumbratana	Two-coloured Bell	81	16	159	85
Eucosma spp.		0	0	0	1
Eudemis profundana	Diamond-back Marble	2	0	2	3
Eudonia angustea	Narrow-winged Grey	0	2	4	9
Eudonia delunella	Pied Grey	0	0	1	2
Eudonia lacustrata	Little Grey	69	14	272	62
Eudonia mercurella	Small Grey	117	141	480	170
Eudonia murana	Moorland Grey	0	3	38	48
Eudonia pallida	Marsh Grey	45	30	68	41
Eudonia spp.		0	0	0	1
Eudonia truncicolella	Ground-moss Grey	0	44	2	33
Eugnorisma glareosa	Autumnal Rustic	0	0	23	1
Eulithis populata	Northern Spinach	0	10	56	48
Eulithis prunata	Phoenix	0	0	1	0
Eulithis testata	Chevron	0	36	21	1
Euphyia unangulata	Sharp-angled Carpet	5	3	8	1
Eupithecia abbreviata	Brindled Pug	0	0	0	2
Eupithecia absinthiata	Wormwood Pug	3	4	4	6
Eupithecia assimilata	Currant Pug	1	3	1	2
Eupithecia centaureata	Lime-speck Pug	22	31	8	48
Eupithecia distinctaria	Thyme Pug	0	4	4	4
Eupithecia dodoneata	Oak-Tree Pug	0	0	2	0
Eupithecia exiguata	Mottled Pug	1	3	1	10
Eupithecia haworthiata	Haworth's Pug	6	0	2	1
Eupithecia icterata	Tawny Speckled Pug	0	3	0	1
Eupithecia inturbata	Maple Pug	24	106	66	28
Eupithecia nanata	Narrow-Winged Pug	0	9	11	4
Eupithecia pulchellata	Foxglove Pug	0	18	5	7
Eupithecia simpliciata	Plain Pug	1	0	0	3
Eupithecia spp.		0	1	0	0
Eupithecia subfuscata	Grey Pug	6	15	4	8
Eupithecia subumbrata	Shaded Pug	0	0	0	1
Eupithecia succenturiata	Bordered Pug	0	2	1	1
Eupithecia tantillaria	Dwarf Pug	0	0	2	0
Eupithecia tenuiata	Slender Pug	1	1	2	0
Eupithecia tripunctaria	White-spotted Pug	6	2	2	3
Eupithecia trisignaria	Triple-Spotted Pug	1	0	0	0
Eupithecia virgaureata	Golden-Rod Pug	0	1	1	1
Eupithecia vulgata	Common Pug	8	21	34	53

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Euplagia quadripunctaria	Jersey Tiger	0	5	0	0
Euplexia lucipara	Small Angle Shades	4	4	2	2
Eupoecilia angustana	Marbled Conch	0	3	0	1
Euproctis chrysorrhoea	Brown-Tail	4	0	7	5
Euproctis similis	Yellow-tail	14	0	17	7
Euthrix potatoria	Drinker	17	7	49	32
Euxoa nigricans	Garden Dart	1	0	2	0
Euxoa tritici	White-Line Dart	0	1	0	0
Euzophera pinguis	Ash-bark Knot-horn	6	6	17	6
Evergestis extimalis	Marbled Yellow Pearl	2	1	0	0
Evergestis forficalis	Garden Pebble	8	19	14	1
Evergestis pallidata	Chequered Pearl	1	2	0	2
Exoteleia dodecella	Pine Groundling	0	2	0	0
Falcaria lacertinaria	Scalloped Hook-tip	0	2	1	2
Galleria mellonella	Wax Moth	2	2	1	0
Gandaritis pyraliata	Barred Straw	110	89	149	33
Gelechia scotinella	Thicket Groundling	18	4	13	20
Gelechia senticetella	Cypress Groundling	1	0	0	0
Gelechia sororculella	Dark-striped Groundling	0	0	1	0
Geometra papilionaria	Large Emerald	0	0	2	1
Globia sparganii	Webb's Wainscot	5	2	2	3
Glyphipterix fuscoviridella	Plain Fanner	0	0	4	2
Glyphipterix simpliciella	Cocksfoot Moth	0	0	6	10
Glyphipterix thrasonella	Speckled Fanner	0	3	1	0
Gortyna flavago	Frosted Orange	0	4	0	0
Graphiphora augur	Double Dart	7	0	0	0
Grapholita funebrana	Plum Fruit Moth	3	0	5	3
Grapholita janthinana	Pale-bordered Piercer	2	1	7	0
Gymnoscelis rufifasciata	Double-striped Pug	19	42	12	5
Gynnidomorpha alismana	Water-plantain Conch	0	4	3	1
Gynnidomorpha vectisana	Small Saltern Conch	0	0	1	0
Gypsonoma aceriana	Rosy Cloaked Shoot	6	0	3	0
Gypsonoma dealbana	Common Cloaked Shoot	11	5	22	4
Gypsonoma oppressana	Poplar Shoot	0	1	1	0
Habrosyne pyritoides	Buff Arches	5	0	1	1
Hada plebeja	Shears	0	5	7	3
Hadena bicruris	Lychnis	6	4	7	9
Hadena confusa	Marbled Coronet	0	1	0	0
Hadena perplexa	Tawny Shears	2	0	0	0
Haplotinea insectella	Drab Clothes	3	3	2	1
Hecatera bicolorata	Broad-Barred White	0	1	1	0
Hedya nubiferana	Marbled Orchard Tortrix	36	44	21	12
Hedya ochroleucana	Buff-tipped Marble	9	3	1	1
Hedya pruniana	Plum Tortrix	22	105	59	53

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Hedya salicella	White-backed Marble	1	0	0	0
Helcystogramma rufescens	Orange Crest	7	3	30	11
Heliothis viriplaca	Marbled Clover	0	5	1	0
Hellinsia carphodactyla	Citron Plume	0	0	1	0
Hemistola chrysoprasaria	Small Emerald	6	0	1	1
Hemithea aestivaria	Common Emerald	5	3	1	2
Hepialus humuli	Ghost Moth	9	6	2	2
Herminia grisealis	Small Fan-foot	4	2	0	3
Herminia tarsipennalis	Fan-foot	11	2	6	9
Hofmannophila pseudospretella	Brown House-moth	11	24	21	10
Homoeosoma nebulella	Large Clouded Knot-horn	0	0	1	0
Homoeosoma sinuella	Twin-barred Knot-horn	8	6	13	12
Hoplodrina ambigua	Vine's Rustic	12	89	81	12
Hoplodrina blanda	Rustic	97	4	151	66
Hoplodrina octogenaria	Uncertain	598	65	583	233
Horisme tersata	Fern	8	4	4	2
Horisme vitalbata	Small Waved Umber	32	39	23	54
Hydraecia micacea	Rosy Rustic	36	70	17	28
Hydrelia flammeolaria	Small Yellow Wave	0	0	1	1
Hydria undulata	Scallop Shell	0	0	3	0
Hydriomena furcata	July Highflyer	159	32	145	77
Hydriomena impluviata	May Highflyer	0	4	2	2
Hylaea fasciaria	Barred Red	0	0	0	1
Hypatima rhomboidella	Square-spot Crest	0	1	0	0
Hypena proboscidalis	Snout	30	24	20	18
Hypena rostralis	Buttoned Snout	0	0	0	1
Hypomecis punctinalis	Pale Oak Beauty	2	0	2	0
Hypomecis roboraria	Great Oak Beauty	1	6	0	4
Hypsopygia costalis	Gold Triangle	0	0	1	2
Hypsopygia glaucinalis	Double-striped Tabby	5	0	1	0
Idaea aversata	Riband Wave	108	28	128	50
Idaea biselata	Small Fan-Footed Wave	65	4	21	27
Idaea dimidiata	Single-dotted Wave	156	68	297	69
Idaea emarginata	Small Scallop	0	0	3	1
Idaea fuscovenosa	Dwarf Cream Wave	37	0	27	9
Idaea rusticata	Least Carpet	8	1	45	19
Idaea seriata	Small Dusty Wave	0	0	0	1
Idaea spp.		0	0	2	0
Idaea subsericeata	Satin Wave	0	0	1	0
Idaea trigeminata	Treble Brown Spot	3	9	1	3
Incurvaria oehlmanniella	Common Bright	0	1	0	1
Ipimorpha retusa	Double Kidney	0	0	1	0
Ipimorpha subtusa	Olive	0	2	0	0

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Isotrias rectifasciana	Hedge Shade	0	3	4	1
Korscheltellus fusconebulosa	Map-winged Swift	0	25	75	77
Korscheltellus lupulina	Common Swift	32	771	2149	1542
Lacanobia contigua	Beautiful Brocade	0	28	11	10
Lacanobia oleracea	Bright-Line Brown-Eye	53	63	59	31
Lacanobia suasa	Dog's Tooth	3	14	15	33
Lacanobia thalassina	Pale-shouldered Brocade	0	20	2	0
Lacanobia w-latinum	Light Brocade	0	0	1	3
Lampropteryx otregiata	Devon Carpet	0	1	0	0
Laothoe populi	Poplar Hawkmoth	54	64	43	49
Lasiocampa quercus	Oak Eggar	1	0	7	2
Laspeyria flexula	Beautiful Hook-tip	12	4	5	3
Lateroligia ophiogramma	Double Lobed	1	0	2	0
Lathronympha strigana	Red Piercer	7	18	14	16
Lenisa geminipuncta	Twin-spotted Wainscot	3	10	1	0
Leucania comma	Shoulder-striped Wainscot	20	8	8	30
Leucania obsoleta	Obscure Wainscot	0	0	0	2
Leucoma salicis	White Satin Moth	0	0	1	0
Ligdia adustata	Scorched Carpet	31	37	15	28
Limnaecia phragmitella	Bulrush Cosmet	6	1	48	1
Lithostege griseata	Grey Carpet	0	0	1	4
Litoligia literosa	Rosy Minor	0	0	0	1
Lobesia abscisana	Smoky-barred Marble	42	23	27	20
Lomaspilis marginata	Clouded Border	61	32	26	24
Lomographa bimaculata	White-Pinion Spotted	0	1	0	1
Lomographa temerata	Clouded Silver	9	17	4	4
Lozotaenia forsterana	Large Ivy Twist	1	0	0	0
Lozotaeniodes formosana	Orange Pine Twist	1	0	0	0
Luperina testacea	Flounced Rustic	311	773	249	693
Luquetia lobella	Sloe Flat-body	0	1	2	1
Lycophotia porphyrea	True Lover's Knot	1	158	752	465
Lygephila pastinum	Blackneck	1	4	2	0
Lymantria dispar	Gypsy Moth	0	0	0	1
Lymantria monacha	Black Arches	23	15	37	16
Lyonetia clerkella	Apple Leaf-miner	1	0	1	0
Macaria alternata	Sharp-Angled Peacock	8	12	7	0
Macaria liturata	Tawny-Barred Angle	0	2	0	0
Macaria notata	Peacock Moth	2	4	1	0
Macdunnoughia confusa	Dewick's Plusia	0	0	0	1
Macrochilo cribrumalis	Dotted Fan-Foot	1	0	0	0
Macrothylacia rubi	Fox Moth	0	36	39	5
Malacosoma neustria	Lackey	5	2	0	0
Mamestra brassicae	Cabbage Moth	9	14	2	1
Marasmarcha lunaedactyla	Crescent Plume	4	0	0	0

Species	**Common name**	**Number of individuals recorded in**			
		2017	**2018**	**2019**	**2021**
Matilella fusca	Brown Knot-horn	0	1	0	0
Meganola albula	Kent Black Arches	1	0	0	0
Melanchra persicariae	Dot Moth	0	0	1	0
Melanthia procellata	Pretty Chalk Carpet	3	4	1	0
Menophra abruptaria	Waved Umber	1	0	1	5
Mesapamea didyma	Lesser Common Rustic	0	0	1	1
Mesapamea didyma/secalis agg.	Common/Lesser Common Rustic	558	408	1247	851
Mesapamea secalis	Common Rustic	0	3	1	0
Mesoligia furuncula	Cloaked Minor	39	51	100	79
Mesotype didymata	Twin-spot Carpet	7	8	0	1
Metalampra italica	Italian Tubic	2	0	4	1
Metzneria lappella	Burdock Neb	3	1	1	0
Metzneria metzneriella	Meadow Neb	7	5	1	5
Miltochrista miniata	Rosy Footman	20	0	26	13
Mimas tiliae	Lime Hawkmoth	1	0	0	0
Mirificarma mulinella	Gorse Groundling	0	6	9	0
Mniotype adusta	Dark Brocade	0	81	42	11
Mompha epilobiella	Common Cosmet	10	4	5	5
Mompha miscella	Brown Cosmet	0	0	0	1
Mompha ochraceella	Buff Cosmet	11	1	1	0
Mompha propinquella	Marbled Cosmet	0	3	0	0
Mompha raschkiella	Little Cosmet	0	1	0	0
Mompha sturnipennella	Kentish Cosmet	0	1	0	0
Mompha subbistrigella	Garden Cosmet	2	7	1	5
Monochroa cytisella	Bracken Neb	0	1	12	1
Monochroa hornigi	Knotweed Neb	0	1	1	0
Monochroa lucidella	Buff-marked Neb	1	0	0	0
Monochroa lutulentella	Black Neb	0	0	1	0
Monochroa palustrellus	Wainscot Neb	14	2	16	4
Monochroa tenebrella	Common Plain Neb	0	0	2	2
Monopis crocicapitella	Pale-backed Clothes	0	0	1	2
Monopis laevigella	Skin Moth	0	1	3	2
Monopis spp.		0	0	1	0
Monopis weaverella	Carrion Moth	9	11	42	45
Mormo maura	Old Lady	4	1	0	1
Morophaga choragella	Large Clothes	0	0	1	0
Musotima nitidalis	Golden-brown Fern Moth	1	0	0	0
Myelois circumvoluta	Thistle Ermine	16	6	7	1
Mythimna albipuncta	White-point	23	8	15	15
Mythimna conigera	Brown-line Bright-eye	40	1	76	26
Mythimna ferrago	Clay	46	2	47	10
Mythimna impura	Smoky Wainscot	1244	64	891	244
Mythimna l-album	L-Album Wainscot	0	0	0	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Mythimna pallens	Common Wainscot	191	770	217	579
Mythimna straminea	Southern Wainscot	58	4	73	83
Mythimna turca	Double-line	0	6	15	8
Naenia typica	Gothic	0	1	0	0
Nemapogon cloacella	Cork Moth	1	0	0	1
Nemapogon koenigi	White-speckled Clothes Moth	0	0	1	0
Nematopogon metaxella	Buff Long-horn	2	12	3	7
Nematopogon schwarziellus	Sandy Long-horn	0	1	1	1
Nematopogon spp.		0	0	0	1
Nematopogon swammerdamella	Large Long-horn	0	0	2	0
Nemophora degeerella	Yellow-barred Long-horn	0	2	0	0
Neocochylis dubitana	Little Conch	0	3	0	1
Neocochylis hybridella	White-bodied Conch	44	64	8	7
Neocochylis molliculana	Ox-tongue Conch	8	49	5	13
Neofaculta ericetella	Heather Groundling	0	21	8	22
Nephopterix angustella	Spindle Knot-horn	0	7	5	0
Niditinea fuscella	Brown-Dotted Clothes Moth	1	0	0	0
Noctua comes	Lesser Yellow Underwing	10	28	316	39
Noctua fimbriata	Broad-Bordered Yellow Underwing	1	1	28	1
Noctua interjecta	Least Yellow Underwing	11	21	35	19
Noctua janthe	Lesser Broad-bordered Yellow Underwing	47	66	44	41
Noctua orbona	Lunar Yellow Underwing	0	1	0	1
Noctua pronuba	Large Yellow Underwing	666	555	2527	378
Noctuid spp.		0	0	1	0
Nola cucullatella	Short-Cloaked Moth	8	1	0	0
Nomophila noctuella	Rush Veneer	6	2	0	2
Nonagria typhae	Bulrush Wainscot	1	3	2	6
Notocelia cynosbatella	Yellow-faced Bell	0	5	11	10
Notocelia roborana	Summer Rose Bell	4	0	5	8
Notocelia rosaecolana	Common Rose Bell	2	0	0	4
Notocelia trimaculana	Triple-blotched Bell	9	20	4	21
Notocelia uddmanniana	Bramble-shoot Moth	11	10	3	14
Notodonta dromedarius	Iron Prominent	1	6	2	2
Notodonta ziczac	Pebble Prominent	1	6	7	0
Nudaria mundana	Muslin Footman	19	2	122	4
Nycteola revayana	Oak Nycteoline	5	0	0	0
Nycterosea obstipata	Gem	1	0	0	2
Nyctobrya muralis	Marbled Green	0	0	2	0
Nymphula nitidulata	Beautiful China-mark	6	4	0	3
Ochropacha duplaris	Common Lutestring	10	5	0	8
Ochropleura plecta	Flame Shoulder	162	351	176	114

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Ochsenheimeria spp.		0	1	0	0
Ocnerostoma friesei	Grey Pine Ermel	0	0	1	0
Ocnerostoma piniariella	White Pine Ermel	0	1	0	0
Odontopera bidentata	Scalloped Hazel	0	2	4	2
Oegoconia deauratella	Scarce Obscure	1	0	1	0
Oegoconia quadripuncta	Four-spotted Obscure	0	3	5	3
Oidaematophorus lithodactyla	Dusky Plume	1	0	0	0
Oligia fasciuncula	Middle-barred Minor	43	171	81	84
Oligia latruncula	Tawny Marbled Minor	41	25	9	14
Oligia strigilis	Marbled Minor	34	104	63	79
Oligia versicolor	Rufous Minor	0	0	3	0
Oncocera semirubella	Rosy-striped Knot-horn	31	0	7	4
Opisthograptis luteolata	Brimstone Moth	59	40	12	25
Opostega salaciella	Sorrel Bent-wing	1	1	4	3
Orgyia antiqua	Vapourer	0	1	0	0
Orthonama vittata	Oblique Carpet	0	1	0	0
Orthotaenia undulana	Woodland Marble	2	19	3	5
Orthotelia sparganella	Reed Smudge	3	2	6	1
Ostrinia nubilalis	European Corn-borer	10	0	19	7
Ourapteryx sambucaria	Swallow-Tailed Moth	9	0	4	1
Oxypteryx atrella	Two-spotted Neb	4	0	2	1
Pammene fasciana	Acorn Piercer	2	0	3	1
Pammene spiniana	Triangle-marked Piercer	0	1	0	0
Pandemis cerasana	Barred Fruit-tree Tortrix	4	7	2	0
Pandemis corylana	Chequered Fruit-Tree Tortrix	0	0	1	0
Pandemis dumetana	Thicket Twist	1	0	1	0
Pandemis heparana	Dark Fruit-tree Tortrix	38	12	29	48
Papestra biren	Glaucous Shears	0	0	2	1
Parachronistis albiceps	Wood Groundling	4	0	0	0
Parapoynx stratiotata	Ringed China-Mark	71	129	155	91
Parascotia fuliginaria	Waved Black	0	0	0	2
Paraswammerdamia albicapitella	White-headed Ermel	3	9	7	5
Paraswammerdamia nebulella	Hawthorn Ermel	8	3	10	2
Parectopa ononidis	Clover Slender	1	2	3	0
Parectropis similaria	Brindled White-Spot	0	0	0	1
Parornix anglicella	Hawthorn Slender	3	13	7	1
Parornix devoniella	Hazel Slender	1	0	1	0
Parornix finitimella	Pointed Slender	3	2	7	1
Parornix spp.		0	1	0	0
Parornix torquillella	Blackthorn Slender	3	24	14	6
Pasiphila chloerata	Sloe Pug	1	0	0	2
Pasiphila rectangulata	Green Pug	19	16	5	16
Pechipogo plumigeralis	Plumed Fan-foot	0	0	0	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Pediasia contaminella	Waste Grass-veneer	1	1	23	4
Pelurga comitata	Dark Spinach	0	0	1	1
Pempelia palumbella	Heather Knot-horn	0	0	0	1
Pennithera firmata	Pine Carpet	1	0	2	0
Peribatodes rhomboidaria	Willow Beauty	164	209	169	179
Peridea anceps	Great Prominent	0	0	0	1
Perizoma affinitata	Rivulet	0	0	0	1
Perizoma albulata	Grass Rivulet	1	0	3	3
Perizoma alchemillata	Small Rivulet	15	2	4	6
Perizoma bifaciata	Barred Rivulet	1	0	0	0
Perizoma flavofasciata	Sandy Carpet	3	3	0	2
Petrophora chlorosata	Brown Silver-Line	0	162	82	77
Phalera bucephala	Buff-Tip	3	4	13	25
Phalonidia affinitana	Large Saltmarsh Conch	0	0	1	0
Phalonidia manniana	Water-mint Conch	1	0	0	1
Pheosia gnoma	Lesser Swallow Prominent	1	7	2	4
Pheosia tremula	Swallow Prominent	4	8	5	9
Phiaris schulziana	Large Marble	0	0	1	0
Philereme transversata	Dark Umber	5	3	2	4
Philereme vetulata	Brown Scallop	1	0	0	0
Phlogophora meticulosa	Angle Shades	3	6	3	5
Photedes fluxa	Mere Wainscot	1	0	1	0
Photedes minima	Small Dotted Buff	4	5	100	45
Phragmatobia fuliginosa	Ruby Tiger	51	33	580	111
Phtheochroa inopiana	Plain Conch	14	2	6	3
Phtheochroa rugosana	Rough-winged Conch	1	1	2	0
Phtheochroa schreibersiana	Scarce Gold Conch	0	0	0	1
Phycita roborella	Dotted Oak Knot-horn	5	17	37	12
Phycitodes binaevella	Ermine Knot-horn	18	1	2	0
Phycitodes maritima	Chalk Knot-horn	1	0	1	0
Phycitodes saxicola	Small Clouded Knot-horn	0	1	0	0
Phyllocnistis unipunctella	Poplar Bent-wing	0	0	1	0
Phyllonorycter blancardella	Brown Apple Midget	0	0	0	1
Phyllonorycter coryli	Nut-leaf Blister Moth	0	1	4	0
Phyllonorycter corylifoliella	Hawthorn Midget	0	0	2	0
Phyllonorycter harrisella	White Oak Midget	1	0	1	2
Phyllonorycter hilarella	Sallow Midget	0	0	2	0
Phyllonorycter joannisi	White-bodied Midget	0	0	1	0
Phyllonorycter junoniella	Upland Midget	0	0	0	1
Phyllonorycter klemannella	Dark Alder Midget	0	1	0	0
Phyllonorycter kuhlweiniella	Scarce Oak Midget	0	0	0	1
Phyllonorycter nicellii	Red Hazel Midget	0	0	7	0
Phyllonorycter quercifoliella	Common Oak Midget	0	0	1	1
Phyllonorycter rajella	Common Alder Midget	0	0	0	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Phyllonorycter salicicolella	Long-streak Midget	0	0	1	0
Phyllonorycter spp.		0	0	2	0
Piniphila bifasciana	Pine Marble	0	1	0	0
Plagodis dolabraria	Scorched Wing	0	3	2	0
Plagodis pulveraria	Barred Umber	0	1	0	0
Platyedra subcinerea	Mallow Groundling	0	0	0	2
Plemyria rubiginata	Blue-bordered Carpet	2	0	1	0
Pleuroptya ruralis	Mother of Pearl	108	86	79	102
Plusia festucae	Gold Spot	3	19	17	7
Plusia putnami	Lempke's Gold Spot	0	0	19	10
Plutella porrectella	Grey-streaked Smudge	0	1	0	0
Plutella xylostella	Diamond-back Moth	298	1217	1551	334
Prays fraxinella	Ash-bud Moth	1	5	1	0
Prochoreutis myllerana	Small Twitcher	0	0	2	0
Pseudargyrotoza conwagana	Yellow-spot Twist	7	2	7	1
Pseudoips prasinana	Green Silver-lines	1	0	1	0
Pseudoswammerdamia combinella	Copper-tipped Ermel	0	4	0	0
Pseudoterpna pruinata	Grass Emerald	0	2	13	13
Psoricoptera gibbosella	Humped Crest	0	0	0	1
Pterophorus pentadactyla	White Plume Moth	41	22	10	2
Pterostoma palpina	Pale Prominent	19	26	11	38
Ptilodon capucina	Coxcomb Prominent	2	0	7	13
Ptilodon cucullina	Maple Prominent	0	1	0	0
Ptocheuusa paupella	Light Fleabane Neb	2	2	0	0
Ptycholoma lecheana	Brindled Twist	0	0	0	1
Ptycholomoides aeriferana	Larch Twist	0	0	1	0
Pyralid spp.		0	1	0	0
Pyralis farinalis	Meal Moth	1	0	0	0
Pyrausta aurata	Small Purple & Gold	1	6	2	2
Pyrausta cingulata	Silver-barred Sable	0	1	0	0
Pyrausta despicata	Straw-barred Pearl	0	4	5	2
Pyrausta purpuralis	Common Purple & Gold	1	4	5	7
Recurvaria leucatella	White-barred Groundling	2	0	3	1
Recurvaria nanella	Brindled Groundling	0	0	1	0
Rhodometra sacraria	Vestal	1	0	0	0
Rhodophaea formosa	Beautiful Knot-horn	2	0	0	1
Rhopobota naevana	Holly Tortrix	6	2	36	27
Rhyacionia pinicolana	Orange-spotted Shoot	1	0	0	0
Rhyacionia pinivorana	Spotted Shoot Moth	0	0	0	2
Rivula sericealis	Straw Dot	152	255	60	81
Roeslerstammia erxlebella	Copper Ermel	0	0	0	1
Rusina ferruginea	Brown Rustic	16	378	189	146
Schoenobius gigantella	Giant Water-veneer	5	1	3	1

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Schrankia costaestrigalis	Pinion-streaked Snout	0	4	0	0
Scoliopteryx libatrix	Herald	6	0	2	5
Scoparia ambigualis	Common Grey	128	184	181	34
Scoparia ancipitella	Northern Grey	0	0	1	0
Scoparia basistrigalis	Base-lined Grey	41	1	42	4
Scoparia pyralella	Meadow Grey	29	61	113	6
Scoparia spp.		0	1	0	1
Scoparia subfusca	Large Grey	63	9	19	45
Scopula floslactata	Cream Wave	0	1	0	0
Scopula imitaria	Small Blood-Vein	5	1	1	1
Scopula immutata	Lesser Cream Wave	0	0	5	0
Scopula marginepunctata	Mullein Wave	0	1	2	1
Scopula ternata	Smoky Wave	0	9	3	2
Scotopteryx chenopodiata	Shaded Broad-bar	126	45	121	163
Scotopteryx luridata	July Belle	0	50	154	85
Scotopteryx mucronata	Lead Belle	0	41	99	54
Scrobipalpa acuminatella	Pointed Groundling	4	25	37	17
Scrobipalpa atriplicella	Goosefoot Groundling	3	9	36	9
Scrobipalpa costella	Winter Groundling	3	1	5	8
Scrobipalpa nitentella	Common Sea Groundling	0	1	0	1
Scrobipalpa obsoletella	Summer Groundling	0	1	4	1
Scrobipalpa ocellatella	Beet Moth	0	0	0	1
Scrobipalpa salicorniae	Sea-aster Groundling	0	1	0	0
Scythris grandipennis	Black Owlet	0	0	2	20
Scythropia crataegella	Hawthorn Moth	2	1	2	0
Selenia dentaria	Early Thorn	18	2	9	16
Selenia lunularia	Lunar Thorn	1	0	1	1
Selenia tetralunaria	Purple Thorn	2	1	0	0
Sitochroa palealis	Sulphur Pearl	0	0	1	1
Sitochroa verticalis	Lesser Pearl	16	3	16	18
Smerinthus ocellata	Eyed Hawkmoth	0	1	4	2
Sorhagenia rhamniella	August Cosmet	0	0	1	0
Sphinx ligustri	Privet Hawkmoth	6	9	7	5
Sphinx pinastri	Pine Hawkmoth	0	0	3	2
Spilonota laricana	Larch-bud Moth	0	0	0	3
Spilonota ocellana	Bud Moth	1	2	13	6
Spilonota spp.		1	0	1	1
Spilosoma lubricipeda	White Ermine	2	244	156	111
Spilosoma lutea	Buff Ermine	48	156	41	36
Spilosoma spp.		0	1	0	0
Spilosoma urticae	Water Ermine	1	2	0	0
Spodoptera exigua	Small Mottled Willow	4	0	1	0
Spuleria flavicaput	Yellow-headed Cosmet	0	0	0	1
Standfussiana lucernea	Northern Rustic	0	0	18	2

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Stauropus fagi	Lobster Moth	2	1	0	2
Stenoptilia bipunctidactyla	Twin-spot Plume	0	0	1	1
Stenoptilia pterodactyla	Brown Plume	9	3	16	22
Stenoptilia zophodactylus	Dowdy Plume	0	0	1	0
Stigmella atricapitella	Black-headed Pigmy	0	0	0	2
Stigmella basiguttella	Base-spotted Pigmy	0	2	0	1
Stigmella hybnerella	Greenish Thorn Pigmy	1	4	0	0
Stigmella microtheriella	Nut-tree Pigmy	0	0	0	1
Stigmella roborella	Common Oak Pigmy	1	2	0	1
Stigmella sakhalinella	Small Birch Pigmy	0	0	1	0
Stigmella samiatella	Chestnut Pigmy	1	2	1	3
Stigmella spp.		0	0	1	0
Stigmella tiliae	Lime Pigmy	0	0	0	2
Stilbia anomala	Anomalous	0	17	0	48
Subacronicta megacephala	Poplar Grey	3	10	1	3
Swammerdamia pyrella	Little Ermel	1	0	2	0
Synaphe punctalis	Long-legged Tabby	0	0	1	0
Syndemis musculana	Dark-barred Twist	0	2	0	3
Syngrapha interrogationis	Scarce Silver Y	0	0	3	0
Tachystola acroxantha	Ruddy Streak	0	0	1	0
Teleiodes luculella	Crescent Groundling	1	0	1	1
Teleiodes vulgella	Common Groundling	6	4	6	1
Teleiopsis diffinis	Large Groundling	0	52	7	20
Tethea or	Poplar Lutestring	0	1	0	1
Thalpophila matura	Straw Underwing	59	158	59	123
Thera britannica	Spruce Carpet	0	4	2	2
Thera cupressata	Cypress Carpet	0	0	1	1
Thera obeliscata	Grey Pine Carpet	1	1	1	1
Tholera decimalis	Feathered Gothic	0	1	0	2
Thumatha senex	Round-Winged Muslin	8	1	7	0
Thyatira batis	Peach Blossom	1	1	1	5
Timandra comae	Blood-vein	56	123	14	25
Tinagma ocnerostomella	Bugloss Spear-wing	0	0	1	1
Tinea pellionella	Case-bearing Clothes Moth	0	1	0	0
Tinea semifulvella	Fulvous Clothes	2	3	2	5
Tinea trinotella	Bird's-nest Moth	1	0	7	2
Tineola bisselliella	Common Clothes Moth	1	0	0	2
Tischeria ekebladella	Oak Carl	0	1	3	0
Tortrix spp.		0	1	1	0
Tortrix viridana	Green Oak Tortrix	4	11	9	7
Trichiura crataegi	Pale Eggar	2	2	1	0
Triodia sylvina	Orange Swift	51	83	35	93
Triphosa dubitata	Tissue	0	1	0	0
Tuta absoluta	South American Tomato Moth	0	0	0	2

Species	Common name	Number of individuals recorded in			
		2017	2018	2019	2021
Tyria jacobaeae	Cinnabar	0	7	14	5
Tyta luctuosa	Four-Spotted	2	3	1	1
Udea ferrugalis	Rusty Dot	2	0	8	6
Udea lutealis	Pale Straw Pearl	45	37	24	50
Udea olivalis	Olive Pearl	4	22	4	8
Udea prunalis	Dusky Pearl	14	0	15	5
Unknown geometrid spp.		0	5	0	0
Unknown micro spp.		1	2	0	1
Watsonalla binaria	Oak Hook-tip	0	6	1	12
Xanthorhoe decoloraria	Red Carpet	0	4	23	42
Xanthorhoe designata	Flame Carpet	4	15	10	6
Xanthorhoe ferrugata	Dark-Barred Twin-Spot Carpet	11	2	8	11
Xanthorhoe fluctuata	Garden Carpet	14	12	17	21
Xanthorhoe montanata	Silver-Ground Carpet	2	73	68	51
Xanthorhoe quadrifasiata	Large Twin-Spot Carpet	10	1	0	0
Xanthorhoe spadicearia	Red Twin-spot Carpet	16	70	48	128
Xestia agathina	Heath Rustic	0	0	1	0
Xestia baja	Dotted Clay	0	5	23	9
Xestia c-nigrum	Setaceous Hebrew Character	434	1162	340	99
Xestia castanea	Neglected Rustic	0	0	5	2
Xestia ditrapezium	Triple-spotted Clay	0	1	15	0
Xestia sexstrigata	Six-Striped Rustic	62	133	64	52
Xestia stigmatica	Square-spotted Clay	6	6	3	2
Xestia triangulum	Double Square-spot	137	21	107	4
Xestia xanthographa	Square-Spot Rustic	61	166	20	52
Xylena vetusta	Red Sword-grass	0	0	1	0
Yponomeuta cagnagella	Spindle Ermine	0	0	3	0
Yponomeuta evonymella	Bird-Cherry Ermine	12	12	10	12
Yponomeuta padella / malinellus / cagnagella		7	14	25	68
Yponomeuta plumbella	Black-tipped Ermine	2	5	7	9
Ypsolopha dentella	Honeysuckle Moth	4	0	1	0
Ypsolopha horridella	Dark Smudge	2	2	0	2
Ypsolopha mucronella	Spindle Smudge	1	0	0	0
Ypsolopha parenthesella	White-shouldered Smudge	1	3	1	0
Ypsolopha scabrella	Wainscot Smudge	12	17	32	19
Ypsolopha sequella	Pied Smudge	3	8	2	2
Ypsolopha vittella	Elm Smudge	1	6	1	1
Zeiraphera isertana	Cock's-head Bell	2	2	9	14
Zeuzera pyrina	Leopard Moth	0	0	1	0

A7.6 Summer bird species list

Table A7.6 List of bird species identified from transects walked in summer in each year of survey, with the number of individuals recorded per species in each year. * indicates species removed prior to analysis (see Appendix A4.3 for more detail).

Species common name	**Number of individuals recorded in**			
	2017	**2018**	**2019**	**2021**
Avocet *	0	0	2	0
Blackbird	468	647	674	628
Blackcap	145	222	318	216
Bullfinch	46	59	51	44
Black-headed Gull *	120	160	230	259
Bittern *	1	0	0	1
Black Grouse	0	2	4	7
Barn Owl	1	5	1	2
Blue Tit	321	493	506	466
Buzzard	61	94	88	113
Carrion Crow	351	560	561	547
Cormorant *	13	8	15	6
Corn Bunting	17	25	21	27
Chiffchaff	165	171	202	227
Collared Dove	67	97	110	91
Corncrake *	0	0	0	1
Canada goose *	109	100	101	133
Chaffinch	284	398	386	286
Cuckoo	21	36	30	19
Common Gull *	2	3	5	14
Common Tern *	5	2	3	2
Coot *	4	12	21	14
Crossbill	0	53	7	14
Common Sandpiper *	0	1	7	3
Coal Tit	38	67	94	49
Curlew	0	103	119	137
Cetti's Warbler	0	0	1	2
Dunnock	202	311	334	312
Dipper *	0	3	5	5
Dunlin	0	1	0	0
Egyptian Goose *	2	2	2	8
Little Egret *	0	2	3	1
Firecrest	2	0	0	2
Fieldfare *	0	6	381	165
Feral Pigeon *	21	169	227	165
Helmeted Guineafowl *	0	0	0	1
Green Woodpecker	65	63	69	80
Gadwall *	6	14	6	4
Great Black-backed Gull *	0	1	3	3
Goldcrest	44	52	71	57
Goosander *	0	1	3	6

Species common name	Number of individuals recorded in			
	2017	2018	2019	2021
Green Sandpiper *	0	0	0	3
Great Crested Grebe *	2	3	2	5
Grasshopper Warbler	0	0	3	4
Greylag Goose *	37	136	133	173
Grey Wagtail	0	25	21	23
Goldfinch	219	389	360	360
Golden Plover	0	106	108	169
Greenfinch	68	102	86	87
Great Spotted Woodpecker	67	83	104	89
Great Tit	172	290	302	249
Garden Warbler	26	28	27	17
Grey Heron	19	32	19	39
Herring Gull *	33	141	721	111
House Martin	87	157	106	130
House Sparrow	256	369	348	311
Great White Egret *	0	0	0	1
Hobby	5	7	2	4
Jay	31	36	57	60
Jackdaw	451	728	1259	2049
Kestrel	30	51	41	53
Kingfisher	1	1	6	3
Red Kite	4	22	21	22
Lapwing	58	355	292	273
Lesser Black-backed Gull *	82	127	139	184
Little Grebe *	0	3	7	8
Linnet	318	522	379	574
Little Owl	2	13	8	7
Little Ringed Plover	2	4	6	0
Lesser Redpoll	0	27	31	26
Long-tailed Tit	80	83	105	95
Lesser Whitethroat	26	37	44	47
Mistle Thrush	25	69	87	50
Mallard	184	350	279	269
Magpie	205	195	199	215
Moorhen	29	31	45	33
Merlin	0	2	1	5
Mandarin *	0	2	12	2
Meadow Pipit	6	580	708	733
Marsh Harrier	1	5	0	2
Mute Swan *	2	35	110	32
Marsh Tit	2	4	5	0
Nightingale	2	2	2	3
Nuthatch	29	36	50	52
Oystercatcher	6	53	52	63
Osprey *	0	0	0	1
Grey Partridge	11	14	26	21

Species common name	Number of individuals recorded in			
	2017	2018	2019	2021
Peregrine	0	4	4	3
Pied Flycatcher	0	3	5	2
Pheasant *	135	319	386	402
Pochard *	0	2	0	0
Pied Wagtail	40	81	81	89
Peafowl *	2	1	1	1
Quail *	0	0	0	1
Robin	288	410	441	521
Reed Bunting	64	119	111	98
Redwing *	0	0	1	3
Red Grouse	0	23	22	70
Redshank	0	9	14	11
Red-legged Partridge *	74	108	143	88
Raven	13	26	50	67
Rook	1332	1353	1586	1597
Redstart	0	10	19	15
Reed Warbler	59	63	61	58
Ring Ouzel	0	3	2	3
Skylark	500	798	793	796
Stonechat	1	37	70	53
Stock Dove	202	343	369	323
Short-eared Owl	0	3	0	7
Spotted Flycatcher	9	13	13	9
Starling	507	402	1276	473
Sparrowhawk	7	13	14	15
Swift	94	303	108	76
Siskin	0	36	21	20
Swallow	256	382	347	410
Sand Martin	2	61	31	51
Snipe	0	36	31	36
Song Thrush	125	154	195	165
Shelduck *	2	33	7	18
Shoveler *	0	4	0	2
Sedge Warbler *	18	15	16	22
Teal *	0	8	4	3
Treecreeper	14	16	13	21
Turtle Dove	0	9	7	2
Stone Curlew *	1	0	0	0
Tawny Owl	7	4	5	4
Tree Pipit	0	10	13	8
Tree Sparrow	7	24	16	10
Tufted Duck *	4	30	9	30
Wheatear	3	62	57	85
Whinchat	0	15	17	14
White-fronted Goose *	0	0	0	14
Whitethroat	257	250	292	239

Species common name	Number of individuals recorded in			
	2017	2018	2019	2021
Woodcock	0	4	1	1
Whimbrel *	0	3	0	0
Wigeon *	0	4	6	3
Woodpigeon	2397	2703	2434	2245
Wren	458	560	636	619
Whooper Swan *	0	0	0	34
Willow Tit	1	1	2	2
Willow Warbler	6	72	112	114
Yellowhammer	211	233	233	233
Yellow Wagtail	27	68	52	75
Zebra Finch *	1	0	0	7
Greylag Goose (Domestic) *	0	3	0	0

A7.7 Winter bird species list

Table A7.7 List of bird species identified from transects walked in summer in each year of survey (2017, 2018, 2019 & 2021). With the number of individuals recorded in each year also given. * indicates species removed prior to analysis (see Appendix A4.3 for more detail).

Species common name	**Number of individuals recorded in**			
	2017	**2018**	**2019**	**2021**
Blackbird	842	825	722	696
Blackcap	0	1	0	1
Bullfinch	124	100	92	67
Brent Goose *	0	14	0	97
Black-headed Gull *	1194	2333	1721	1333
Black Grouse	0	2	2	5
Brambling	20	16	6	4
Barn Owl	1	4	4	4
Bewick's Swan *	0	4	0	0
Blue Tit	576	589	640	628
Black-tailed Godwit *	0	0	0	1
Buzzard	123	131	166	157
Carrion Crow	523	663	597	622
Cormorant *	212	43	19	12
Corn Bunting	21	42	33	20
Chiffchaff	4	21	16	11
Collared Dove	199	119	97	93
Canada goose *	117	87	81	152
Chaffinch	1024	1037	1322	1418
Common Gull *	458	1328	1312	1121
Coot *	8	11	23	4
Crossbill	0	28	25	16
Coal Tit	52	89	79	69
Curlew	0	90	119	84
Cetti's Warbler	0	0	1	2
Dunnock	391	307	291	314
Dipper *	0	3	2	8
Dunlin	0	0	0	2
Egyptian Goose *	8	4	2	6
Little Egret *	4	3	2	1
Firecrest	2	0	0	4
Fieldfare	3667	3648	3508	3451
Feral Pigeon *	142	281	488	458
Helmeted Guineafowl *	0	0	3	0
Green Woodpecker	56	59	63	67
Gadwall *	0	15	15	46
Great Black-backed Gull *	10	4	4	0
Goldcrest	90	96	102	102
Goosander *	0	8	2	4
Green Sandpiper *	2	1	2	1
Great Crested Grebe *	1	0	2	3

Species common name	Number of individuals recorded in			
	2017	2018	2019	2021
Goshawk	0	1	1	0
Greylag Goose *	212	155	323	203
Grey Wagtail	5	8	12	12
Goldeneye *	0	0	0	1
Goldfinch	807	497	602	596
Golden Plover	797	4963	663	867
Greenfinch	182	141	273	161
Great Spotted Woodpecker	67	88	83	80
Great Tit	342	399	343	297
Grey Heron	23	19	28	32
Hawfinch	103	0	14	0
Herring Gull *	496	98	226	196
Hen Harrier	0	2	3	0
House Sparrow	336	463	340	302
Great White Egret *	1	0	1	1
Jay	47	77	70	89
Jackdaw	2994	4883	3974	3429
Jack Snipe *	0	0	0	1
Kestrel	43	57	79	72
Kingfisher	1	4	0	4
Red Kite	11	36	26	23
Lapwing	1817	1995	1363	785
Lesser Black-backed Gull *	391	59	87	144
Long-eared Owl	0	0	0	3
Little Grebe *	3	2	3	5
Linnet	2412	1118	2645	2003
Little Owl	5	3	3	2
Lesser Redpoll	59	15	1	15
Long-tailed Tit	225	254	304	232
Mistle Thrush	54	67	84	94
Mallard	367	337	424	317
Magpie	235	230	245	226
Moorhen	29	39	50	47
Merlin	1	3	2	3
Mandarin Duck *	1	6	8	2
Meadow Pipit	782	707	856	649
Marsh Harrier	2	1	3	1
Mute Swan *	157	80	67	83
Marsh Tit	13	16	12	7
Mediterranean Gull *	0	0	2	17
Nuthatch	31	45	49	41
Oystercatcher	1	19	26	30
Grey Partridge	42	92	62	55
Peregrine	5	10	9	11
Pink-footed Goose *	0	0	424	610
Pheasant *	510	749	728	569

Species common name	Number of individuals recorded in			
	2017	2018	2019	2021
Pintail *	0	0	0	4
Pied Wagtail	302	177	212	190
Robin	509	486	566	602
Reed Bunting	597	455	536	405
Redwing	1205	1566	2147	2053
Red Grouse	0	49	62	133
Redshank	1	5	1	1
Red-legged Partridge *	345	569	534	294
Raven	19	76	80	90
Rook	1769	2096	1495	1913
Ring Ouzel	0	0	0	2
Skylark	927	950	935	897
Snow Bunting	0	0	0	1
Stonechat	6	36	47	66
Stock Dove	561	461	361	361
Short-eared Owl	0	3	3	1
Starling	2605	6644	3785	3629
Sparrowhawk	16	21	21	22
Swift	2	0	0	0
Siskin	19	77	47	60
Snipe	37	60	35	121
Great Grey Shrike *	0	0	0	1
Song Thrush	231	237	251	211
Shelduck *	0	2	1	0
Shoveler *	0	4	15	0
Teal *	78	61	24	21
Treecreeper	12	24	16	17
Tawny Owl	7	1	2	1
Tree Sparrow	167	80	100	71
Tufted Duck *	19	8	61	52
Wheatear	0	1	1	0
Water Rail *	1	1	0	0
White-fronted Goose *	0	0	36	1
Woodcock	15	19	10	11
Wigeon *	351	123	719	286
Woodpigeon	10190	7735	9249	5195
Wren	255	386	404	358
Whooper Swan *	973	1148	74	210
Willow Tit	0	0	2	4
Yellowhammer	652	739	747	622
Feral/hybrid mallard type *	0	0	12	7

A7.8 Bat species list

Table A7.8 List of bat species identified from all survey detectors, and the encounter rate (from total number of checked recordings across all nights of sampling from the original data set) per species recorded during the survey, combining all years 2018, 2019, 2021, and all 54 survey squares.

Species	**Total no. recordings**	**Total no. of 1-km squares**
Common Pipistrelle *Pipistrellus pipistrellus*	778,841	54
Soprano Pipistrelle *Pipistrellus pygmaeus*	178,575	54
Noctule *Nyctalus noctula*	61,455	54
Leisler's Bat *Nyctalus leisleri*	3,567	42
Daubenton's Bat *Myotis daubentonii*	26,528	54
Natterer's Bat *Myotis nattereri*	27,047	54
Whiskered/Brandt's Bats *Myotis mystacinus/brandtii*	34040	53
Barbastelle Bat *Barbastella barbastellus*	11,885	29
Brown Long-eared Bat *Plecotus auritus*	13,973	54
Serotine *Eptesicus serotinus*	1,306	31
Rarer bats		
Nathusis' Pipistrelle *Pipistrellus nathusii*	224	10
Lesser Horseshoe Bat *Rhinolophus hipposideros*	415	10
Greater Horseshoe Bat *Rhinolophus ferrumequinum*	538	9
Grey Long-eared Bat *Plecotus australis*	2	1
Alcathoe Bat *Myotis alcathoe*	1	1
Bechstein's Bat *Myotis bechsteinii*	4	2

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