Operation Wallacea Science Report

2019, Târnava Mare, Transylvania

Angofa, near Sighișoara. JJB.

This report has been compiled by Dr Joseph J. Bailey (Senior Scientist for Operation Wallacea and Lecturer in Biogeography at York St John University, UK) on behalf of all contributing scientists and the support team.

The project is the result of the close collaboration between Operation Wallacea and Fundaţia ADEPT, with thanks also to York St John University.

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Operation Wallacea
Conservation research through academic partnerships

FUNDATIA ADEPT

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1 THE 2019 TEAM

Sincere thanks go to everyone involved in the project, past and present, including staff and volunteers from both Adept and Opwall, without whom we could not continue to collect our long-term dataset to support ongoing efforts in this fantastic part of the world.

The names of each person in the 2019 science and support teams are listed below. Equally, thank you to the school students and teachers, dissertation students, and research assistants who contributed huge amounts of time and energy towards the 2019 field season.

We also thank the local residents and farmers who host us, partake in surveys, and let us roam around in their villages and on their land.

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Support team

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2 ABBREVIATIONS & DEFINITIONS

Adept	Fundația ADEPT, Romania; *https://fundatia-adept.org/*
BirdLife	BirdLife International; *http://www.birdlife.org/*
BPC	Bird point count (one of our surveys)
EEA	European Environment Agency; *https://www.eea.europa.eu/*
IUCN*	International Union for the Conservation of Nature; *https://www.iucn.org/*
NA	Not applicable
NR	Not recorded
Opwall	Operation Wallacea, UK; *http://www.opwall.com/*
PECBMS	Pan-European Common Bird Monitoring Scheme; *https://www.ebcc.info/pecbms/*
YSJ	York St John University, UK; *https://www.yorksj.ac.uk/*
§	Section indicator

* For details on how the IUCN Red List categorisation works in relation to the categories listed below, please see *https://iucn-csg.org/red-list-categories/*.

- Extinct (**EX**) → Extinct in the wild (**EW**) → Critically endangered (**CR**) → Endangered (**EN**) → Vulnerable (**VU**) → Near threatened (**NT**) → Least concern (**LC**)
- Data deficient (**DD**); Not evaluated (**NE**).

3 INTRODUCTION & BACKGROUND

3.1 The landscape

There exists a wealth of literature on this landscape's culture, society, grasslands, and biodiversity (e.g. Akeroyd, 2006; Akeroyd & Page, 2006, 2011; Jones *et al.*, 2010; Akeroyd & Bădărău, 2012a,b), and the river itself (e.g. Blaga, 2007). In particular, John Akeroyd's publication (Akeroyd, 2006), in collaboration with Fundația ADEPT, provides a broad overview of the landscape, defining it as one "that Europe has mostly lost, where a wealth of plants and animals thrives alongside traditional agriculture" (p. 9).

Near Viscri, JJB

3.2 Aims and scope

This report summarises the data gathered by Operation Wallacea's (Opwall; see §3.5) Transylvania project during the summer of 2019, in collaboration with our in-country partner Fundația ADEPT ('Adept').

Having started in 2013, 2019 marked the **seventh year**. The project is based on annual surveys across the landscapes in and around several villages in the **Târnava Mare Natura 2000 site** (*EEA factsheet*). Surveys take place across several weeks in the summer, from mid-June to early-August.

Our ongoing aim is to assess the effectiveness of maintaining the traditional agricultural practices in protecting this outstanding landscape and its species. I.e.: **How is biodiversity changing and why?** Opwall's surveys provide annual data on a range of biodiversity and farming criteria.

These data are used by Fundația ADEPT, a Romania-based NGO, to help guide their farming and conservation initiatives. Meanwhile, university dissertation students and researchers use the data to for scientific questions across a range of taxa and fields (§3.6).

This report gives an overview of the 2019 state of affairs in terms of agriculture and biodiversity. Data from previous years are shown for comparison where appropriate, but please refer to previous reports for specific details. Changes in the data over a period of several years can be used to reveal how the biodiversity of Târnava Mare is changing, for example in response to shifting agricultural practices.

3.3 Caveats

Caution is urged when comparing differences between 2019 and previous years because there is a variety of factors that can cause the numbers to be different, including slight changes to the methodology (see §4), differences in the dates of the surveys (Table 4.3a), natural population fluctuations, and availability of farmers to interview (see §4.8). In particular, the weather conditions can vary substantially from year to year. This has an impact on the number of surveys that can be undertaken and can affect vegetation phenology, and the abundance and activity of wildlife (particularly butterflies and small mammals). The preservation of large mammal signs is also affected by rainfall and resultant ground conditions.

The dataset will become increasingly robust as the years go on and the dataset grows; in time, such natural variability will therefore become less significant and our ability to identify reliable trends will increase. The data thus far are still very valuable, though, and point towards potential changes across multiple taxa and locations. Indeed, the value of these data, which will only increase, is that they can be used to give a first warning that significant changes may be occurring, or reassurance that the biodiversity is stable or doing particularly well. Additionally, the data can start to be used to investigate spatial variation. For example, biodiversity and the land use of the surveyed villages can be compared to investigate the influence of land cover (as a function of land use) on the composition and abundance of species.

3.4 Wider context for 2019

The 2019 science report has been compiled by Dr Joseph J. Bailey, who, as of 2019, has taken over the Senior Scientist role from Dr Bruce Carlisle. JJB visited the field site for ten days in 2019 to allow overlap with BC to carry out the handover and make for a smooth transition.

The reports from 2013 – 2018 were becoming increasingly large as the datasets grew. This report can be seen as a hybrid between the reports from previous years and how I hope future reports will look. There was not time this year to make all of the changes that I wanted to make to simplify

how this increasingly complex dataset is presented. This is because of time pressures in my role as a lecturer caused by COVID-19, and the already limited time available between the handover and having to sort and process all of the data to write this report.

One of the main changes implemented this year is that the appendices have been made available electronically, to limit the length of the report itself. Figures and tables in the main report have been simplified. Meanwhile, results sections have been streamlined. Ultimately, with the planned changes in the future, this will ensure the report is as useful as it can be for its diverse readers, including Adept, Opwall students and staff, and policymakers. Future directions are discussed in section 6. Given that this is the first of these reports I have written, please email me (see §1) and I will consider that feedback going forwards.

Finally, it is worth noting the current uncertainty caused by COVID-19. As I write this in March 2020, this year's field season remains uncertain. Whatever happens, research projects (see §3.6) will continue, and data collection will recommence in earnest as soon as it is safe to do so.

3.5 What is Operation Wallacea?

Taken from *https://www.opwall.com/about-opwall/* (accessed February 2020):

> *Operation Wallacea (Opwall) is a conservation research organisation that is funded by, and relies on, teams of student volunteers who join expeditions for the opportunity to work on real-world research programmes alongside academic researchers.*
>
> *Most science programmes abroad that deliver research outcomes are funded on a short-term basis by grants with typically tightly restricted aims. Long-term projects covering large bio-geographical scales that can incorporate more than one ecosystem are rare. By adopting a volunteer funded model, Opwall does not suffer from those restrictions and can draw upon researchers from a wide range of different disciplines and academic institutions and create long-term research projects.*
>
> *Those researchers and academics also separate Opwall from other volunteer organisations, allowing a truly research orientated project. You can also find out more about people's experiences and our projects at the Opwall Blog*.

3.6 Research projects and planning

Within the general infrastructure of the Transylvania project, multiple distinct research projects are in progress and/or planning or awaiting additional years of data. There is also scope to incorporate new projects – please get in touch regarding anything below of in Future Directions (§6).

Updates will be provided in these annual reports, but are also available more frequently via ResearchGate: *https://www.researchgate.net/project/Biodiversity-change-in-traditionally-managed-grasslands*.

3.6.1 In progress

- Small mammals. A group of us have started working on a paper on cycles in the small mammal populations across several years of data.
- Extensive GIS data collation and land cover mapping using remote sensing (satellite data; e.g. SENTINEL) to support all other projects.
- There is a plant-related paper in progress, making use of land use history data.

3.6.2 In planning

- Plant-pollinator assessments, which will hopefully be supported by additional pollinator data in future field seasons
- A plant indicator species paper based on a previous dissertation student's project.
- Awaiting more years of camera trap data under the new grid system, a large mammal paper is planned

3.7 Outreach

We were visited by TV channels from both Romania* and Malta** this year! Both were for news features about biodiversity and the work we are doing in Târnava Mare. Several members of the team spoke to the reporters, including staff and students.

* Here is the Romanian report: *https://observator.tv/social/natura-animalele-oamenii-transilvania-atrag-sute-studenti-toata-lumea-302209.html*.

** We welcome many school groups from Malta visiting our site and learning about the science.

4 METHODS

4.1 Village summary

Table 4.1a The villages (and their surrounding landscapes) studied throughout the duration of this project, from 2013 to present, with their location and link a to Google Maps Satellite View. Not every village is studied every year (see below).

Village name	Latitude, longitude
Angofa	46.184752, 24.781135 (*Google Maps*)
Apold	46.124051, 24.817104 (*Google Maps*)
Criț	46.119944, 25.017966 (*Google Maps*)
Daia	46.146573, 24.901602 (*Google Maps*)
Mălâncrav	46.109608, 24.649934 (*Google Maps*)
Meșendorf	46.089556, 24.982956 (*Google Maps*)
Nou Săsesc	46.112849, 24.603225 (*Google Maps*)
Richiș	46.098687, 24.480787 (*Google Maps*)
Viscri	46.054687, 25.093027 (*Google Maps*)

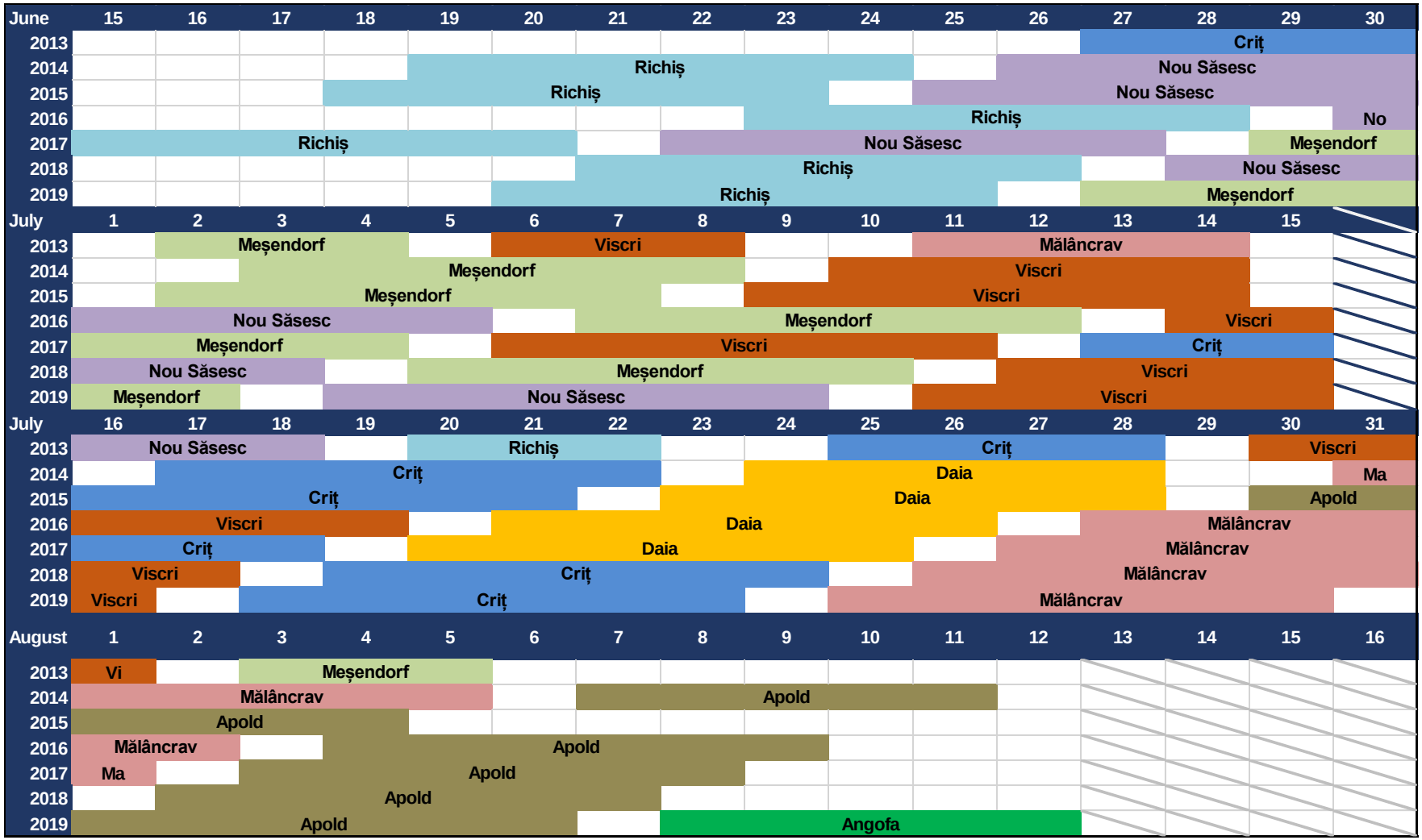
4.2 Villages visited in each year

Table 4.2a A summary of the villages studied in each year. A shaded cell indicates that the village was visited and surveyed for at least three days and nights. The number indicates the order in which the village was visited, each visit lasting for at least three days (many for five or days; see Table 4.3a).

Village name	2013	2014	2015	2016	2017	2018	2019
Angofa	-	-	-	-	-	-	8
Apold	-	8	7	7	8	7	7
Criț	1 + 7	5	5	-	5	5	5
Daia	-	6	6	5	6	-	-
Mălâncrav	4	7	-	6	7	6	6
Meșendorf	2	3	3	3	3	3	2
Nou Săsesc	5	2	2	2	2	2	3
Richiș	6	1	1	1	1	1	1
Viscri	3 + 8	4	4	4	4	4	4

4.3 Survey dates per year

Table 4.3a The specific dates on which each village was surveyed in each year. The fact that we cannot be in the same village at the same time each year should be considered when interpreting results herein.



4.4 N.B. for 2019

- We added a new village to our study locations: Angofa, near Sighişoara (Table 4.1a).
- The enhanced grid system for large mammal camera trapping was maintained.

4.5 Land use mapping

No additional land use mapping took place in 2019, though these data continued to be recorded by the bird survey team and will be used going forwards. An extensive land cover and land use mapping operation using remote sensing and GIS data is underway and will be in place for the next field season. It will be detailed in the next science report.

4.6 Overview: all surveys

Surveys for plants, butterflies, bird point counts (BPC), and large mammal signs are carried out along **transects**. These transects are three linear (not straight-line) survey routes per village. Each route was selected in 2013, with the aim of traversing land cover types and land uses that are representative of the village's surroundings. The routes are constrained by accessibility.

The **central transect** is approximately **4 km long** and runs along the valley floor, upstream and downstream of the village. This transect runs through the village, usually alongside a road, near to the stream, and through more intensely farmed land. The **west and east transects** are approximately **6 km long** and each takes a roughly semi-circular route from the valley floor up the valley sides, usually into less intensely farmed land, meadow grassland, pasture, and woodland. There have been no significant changes to the transect locations between survey years. Overall, there are seven main survey teams, with birds and large mammals covering two survey types each (Table 4.6a).

Survey restrictions exist due to weather and dogs guarding the sheep flocks. The dogs were particularly problematic for Viscri's east transect in 2018 and 2019. Bad weather can also affect survey frequency and quality. This can be problematic and should be considered when viewing results, given that we only have five or six days at each village throughout the field season.

Handheld GPS devices are used to record the location of all surveys and observations.

Table 4.6a A summary of all surveys conducted each year across all villages.

Survey name	Taxonomic group/s	Number of species across all years	Notes
Farmer interviews	NA	NA	Ad hoc, according to which farmers are available.
Grassland plants	Indicator plant species derived from (Akeroyd & Bădărău, 2012a)	31	Same locations each year. Spatially coincident with butterfly surveys
Grassland butterflies	All butterflies and moths	141	Same locations each year. Spatially coincident with plant surveys
Birds: Point counts (BPC)	All birds (seen and heard)	119	Same locations each year.
Birds: Mist netting	All birds (caught)	63 [2019 only]	
Bats	All bats (seen, heard, caught)	16 [2019 only]	
Small mammals	Small, ground-based mammals (caught)	14	Does not include bats.
Large mammals: Camera traps	All large mammals (seen on camera trap)	18	All 'large' mammals from badgers, hares, and martens up to wildcats and bears. Signs include scats and tracks. Smaller mammals (e.g. squirrels) may also be recorded.
Large mammals: Signs	All large mammals for which evidence is found	18	

4.7 Data processing & display

'Biodiversity' is assessed using a range of metrics in the results.

1. **Species richness**: How many species are in a given area
2. **Abundance**: How many individuals of a given species are in an area
3. **Simpson's Evenness Index**

$$D = \frac{N(N-1)}{\sum n_i(n_i-1)}$$

Where N = the total number of individuals of all species

n_i = the number of individuals of species i

*Simpson's Index (D) is a measure of **similarity**, for which a higher value is associated with more even communities. It is affected quite strongly by common (dominant) species and overall evenness.*

4. **Shannon's Index**

$$H = \frac{N \ln N - \sum(n_i \ln n_i)}{N}$$

Where N = the total number of individuals of all species

n_i = the number of individuals of species i

*Shannon-Weiner (or simply Shannon's) Index (H) is a **diversity** metric that increases for more diverse communities. It is more strongly affected by species richness and rare species.*

Metrics 1 and 2 are used across all taxa. Metrics 3 and 4 are additionally used for plants; butterflies; and BPC.

4.7.1 Temporal trends

To assess trends through time, biodiversity data (using one of the metrics above) are ranked and a Spearman's Rank Correlation is carried out against these data and year. Significance tests are used to determine whether the correlation is statistically significant. These ranked data are used for: farm surveys; plants; butterflies; and BPC.

Angofa is not included in any of these temporal analyses because we only have one year of data thus far.

4.7.2 Data presentation

Correlation results in tables are typically colour-coordinated, such that negative trends are in blue and positive trends in pink/red. For results tables that do not use correlation results, blue-red scales are often used, whereby red is a high value and blue is low value.

4.8 Farmer interviews

A farm surveyor and translator (if required) approaches as many farmers as possible in the village. The data obtained via these surveys are, therefore, heavily dependent on farmers' availability and willingness to volunteer to take part. This means that data should be viewed as indicative, not exhaustive, given that the same farmers are not necessarily surveyed each year.

There are no farm data for 2016 for all villages and this survey is not carried out at Angofa (new location in 2019).

Questions are asked on the following topics:

- Basic information: house number; length of time area farmed
- Total area farmed and how much of that is arable vs pastoral
- Whether they use shared grazing lands
- Number of different types of livestock and which of these are increasing/decreasing
- Number of conflicts between livestock/dogs and wolves/bears
- Date of first hay cut, how it was cut, and area of land used for hay and silage
- Participation in Agri-environment schemes
- How things are changing / future plans

4.9 Grassland plants

The same method and sites have been used since 2013 (apart from some villages not being surveyed in certain years; see §4.2). The survey plots exist at roughly equal intervals along the transects (see §4.6). They are spatially coincident with the butterfly plots.

The survey locations were decided by an expert botanist assessing the grassland along the transect. The area was visually partitioned into high, medium, and low nature value (HNV, MNV, LNV) categories based on indicators such as the presence of farm weed species, evidence of current use, shrub encroachment and abundance, and the variety of wildflowers. On each transect a minimum of six plot locations were identified with the target of two for each H, M, and LNV. This was not always achieved due to the prevalence or absence of these types.

Grassland plant **plots are 50m x 5m**. This is large for a botany plot but allows for an overview of the species present across an area more equivalent to the butterfly plots than a small, traditional quadrat. The method also ensures engagement from everyone in the survey group, which typically consists of school and university students on the Opwall expedition. Identification and counts are quick over such a large area because there are multiple surveyors.

The surveyors slowly walk the length of the plot counting the number of individuals of 31 species. 30 of these are defined as indicators of HNV dry grassland in Fundația ADEPT's guide *Indicator Plants of the High Nature Value Dry Grasslands of Transylvania* (Akeroyd & Bădărău, 2012a). Betony is also counted because, although it is an indicator for damp grasslands, it is relatively abundant and widespread on the surveyed grasslands.

The species that are in flower change as the fieldwork season progresses. Surveying a plot on a different date is likely to give different results. This is of particular relevance when comparing data from different years to assess change. Additionally, as the season progresses, the number of mown fields increases and the number of fields available for survey, with standing wildflowers, decreases. This could affect the representativeness of a village's plant surveys and could also affect comparisons between years if the survey date is not similar. In 2018 there was a new survey team leader, who continued into 2019.

4.10 Grassland butterflies

The same method and sites have been used since 2013 (apart from some villages not being surveyed in some years; see §4.2). The survey plots exist at roughly equal intervals along the transects (see §4.6). They are spatially coincident with the botany plots and, therefore, the same method was used to define them (see §4.9 above).

Butterfly **plots are 50m x 10m**. All **butterflies and moths** seen in a five-minute walk along the length of the plot are counted by the survey team, led by a trained entomologist. Butterfly counts take place between 10:00 and 16:00 to avoid the cooler parts of the day. Butterfly counts do not take place if it is raining. However, there still exists wide variation in the abundance of butterflies due to weather conditions and time of day.

The team aims to repeat the survey of each plot two or three times (depending on suitable weather conditions) to reduce the impact of weather conditions on the data. In case of mowing or problems with dogs (guarding sheep flocks), there are proximal comparable sites that the surveyor can use.

All species are recorded, but we have a particular interest in the indicator species, as recorded in Adept's publication *Indicator butterflies and moths of the High Nature Value dry grasslands of*

Transylvania. The data are contributed to the *European Butterfly Indicator for Grassland Species* reports, the *most recently published one of these being in 2015* (Van Swaay *et al.*, 2016).

4.11 Birds: Point count (BPC)

The same method and sites have been used since 2014 (apart from some villages not being surveyed in some years; see §4.2). There were some surveys in 2013, but these were not in the permanent locations that were established in 2014, so data from 2013 are not included when looking at temporal trends.

The survey plots exist at roughly 500m intervals along the transects (see §4.6) and typically not at exactly the same locations as the botany and butterfly surveys. Each point count lasts for ten minutes and all individuals seen or heard are counted. The surveys begin soon after dawn, between 0545 and 0615, and are generally completed before midday.

The time of year and amount of mown grass will affect the numbers and species of birds being recorded. Meanwhile, there is a very noticeable decrease in the amount of bird song and activity as the morning progresses. For this reason, points further along a transect tend to have fewer observations. Most surveys were therefore repeated, walking the transect in the opposite direction to compensate for the time of day effect. Surveys are not run in heavy rain.

The point count data are shared with *Milvus* (OpenBirdMaps database) and the *Ornithological Society of Romania* (Ornitodata).

4.12 Birds: Mist netting

In addition to the point counts, mist netting and ringing also operates. Nets are set up at dawn and at dusk, typically in scrub areas adjacent to farmland and across bird movement corridors. The time that the birds are captured for and handled is kept to a minimum and those doing this are fully qualified.

The mist netting data offer valuable insights into bird morphology, movement, and behaviour.

There are two additional locations to the usual villages in these data: Brădeni and Buneşti.

The ringing data are shared with *Milvus*.

4.13 Bats

Our bat surveys use a multi-method approach incorporating mist nets, harp traps, and acoustic recordings. Surveyors are fully qualified for handling. The bat report was compiled by Dr Patrick Wright and the methods are embedded alongside the results within §5.7.

4.14 Small mammals

Reliable data exist for 2016 – 2019. The method relies on grids of 4 x 5 or single lines of 20 live traps, which are laid out in different habitat types: low and high nature value (LNV and HNV), grassland, and scrub/woodland edge, depending on the characteristics and shape of the habitat. Plastic tube traps are used and their relatively low cost means that more traps can be purchased and replaced if damaged or stolen.

The traps are put in place for four consecutive nights at each village: traps are set each evening and checked early the following morning to minimise the time that animals are trapped for. Mice, voles, and shrews are the target species. Weight and size are recorded, and parasites are removed and kept for further study. The animals are released after as little handling as possible.

The trap design is also considered to be relatively good in terms of animal welfare, which is of the utmost importance and surveyors are experienced in handling small mammals. The locations of some trap grids are adjusted each year to reduce chance of damage or theft, and due to habitat changes from mowing and grazing.

4.15 Large mammals: Camera trap

Camera trap surveys have taken place since 2014. The number and quality of cameras has grown throughout this time and the methodology has subsequently been gradually enhanced.

Camera traps are now set up in a large grid formation in woodland locations around each village for four or five days and nights. This length of time is not typical of a camera trapping operation, which would ideally be longer. However, logistical constraints dictate this timeframe and we still get an abundance of useful sightings. Each large mammal sighting is recorded as the videos are watched after collection. All reported data (i.e. total observations per species) are controlled for using the length of time the cameras were recording for.

Data from 2015 generally have no end times and dates (i.e. when the camera was turned off and collected). These 2015 data are, therefore, largely unusable (except for Apold, Criț, and Daia) because it is impossible to calculate sightings per time, which is required to control for sampling effort for this kind of survey.

4.16 Large mammals: Signs

The survey of large mammal signs involves walking the east and west transects, omitting the central village transect (see §4.6). The lead surveyor records sightings, scat, tracks, digging, and any other signs of large mammal presence. The same technique and routes have been used since 2014.

These data are used in an opportunistic fashion, rather than as a formal means of long-term monitoring. This means that in the reported data, species observations are recorded, but sampling effort between years need not be controlled for because these data, whilst still important, are simply used to supplement the more formalised camera trapping operation.

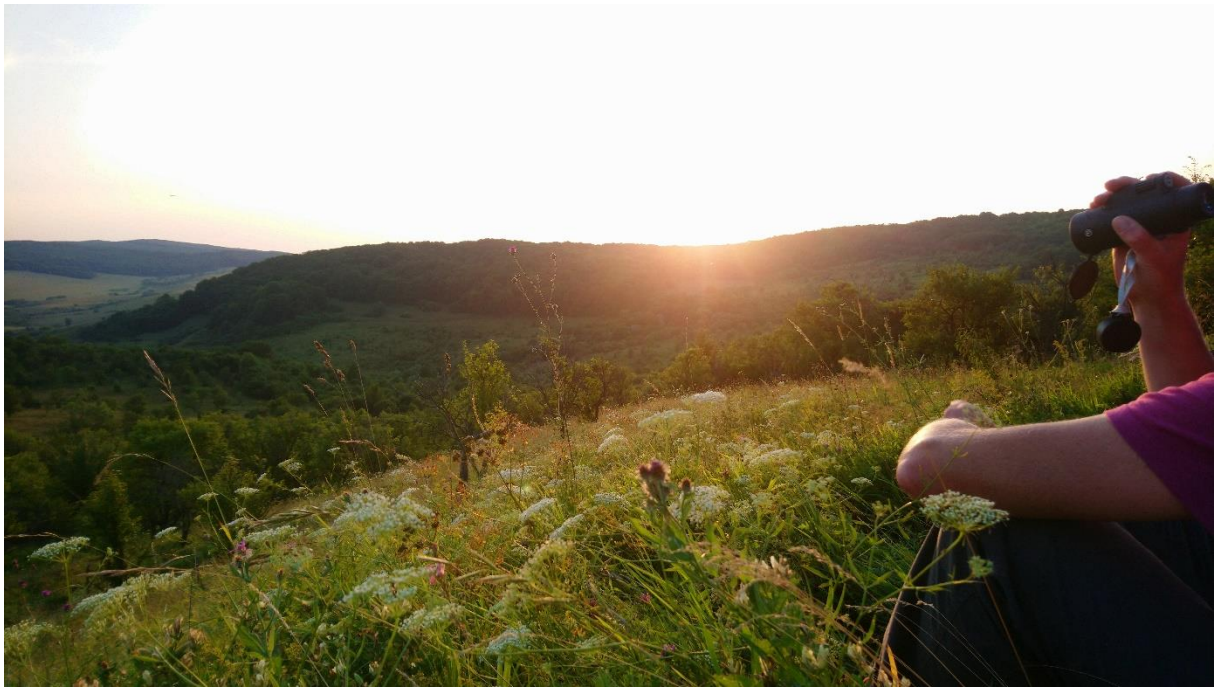
A mown field, near Viscri, with storm clouds overhead. JJB.

5 RESULTS

5.1 Highlights

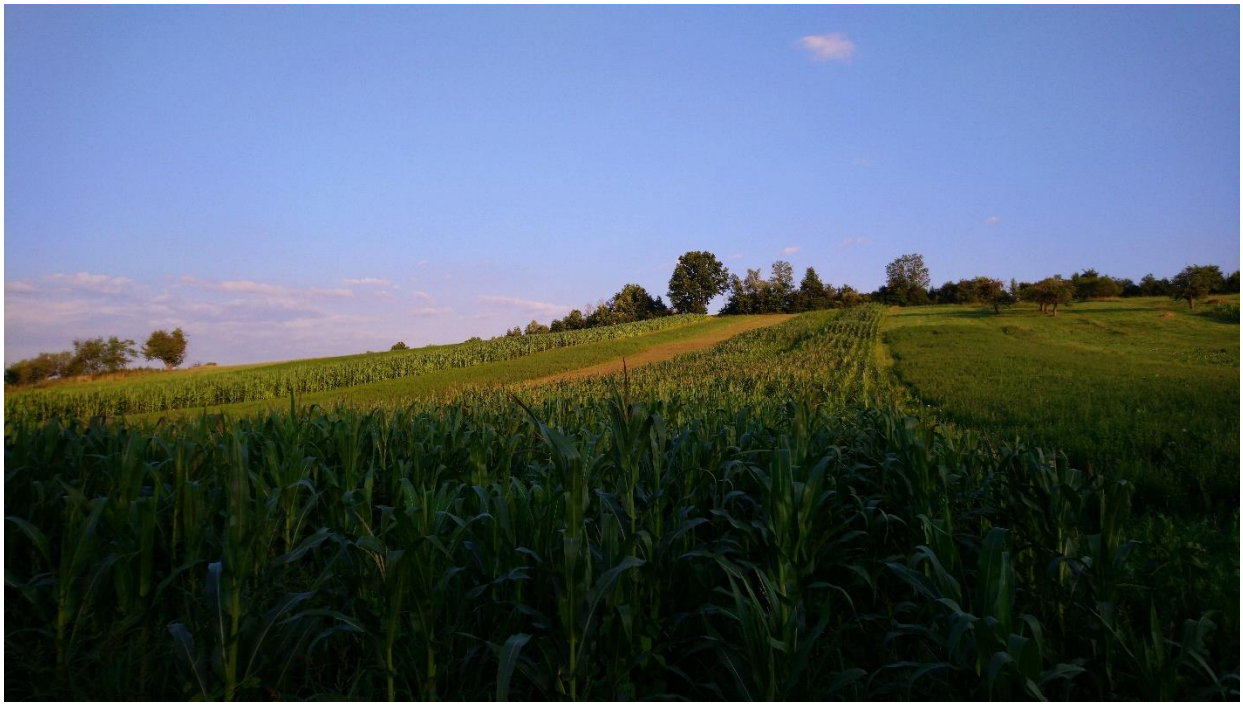
Survey-specific results, including a summary of key trends are presented in each section below and these should be referred to in turn. However, a few of the key messages are:

- The **database** is still growing and, whilst significant trends are emerging, **we need more years of data** to speak with confidence about many of the species and locations and, indeed, the overall change in biodiversity and farming practices.
- Regarding **farming** practices, patterns of hay cutting might be changing, with the month of the first cut getting earlier. Conflicts between livestock and their guard dogs and large mammals may be becoming more frequent.
- A number of **plants** show significant trends if increase and decline. For example, Sainfoin (*Onobrychis viciifolia*) is decreasing in Apold, Richiș, and perhaps also in Meșendorf, making it one of the species with the most widespread declines.
- The **butterfly** data are the most complicated and inconsistent, but Daia might be seeing the most substantial declines in butterfly biodiversity according to multiple metrics (though, we have not visited Daia since 2017).
- For **bird point counts**, Simpson index is significantly increasing through time for several plots, suggesting that those communities are becoming more even; i.e. similar abundance across all species, rather than a few species dominating.
- Richiș might be seeing a decline in **large mammals**.



Looking for bears at sunset, near Criț. JJB.

5.2 Farmer interviews



Farmland in Criț, at sunset. JJB.

The results are thus far based on a limited temporal dataset (up to six years, with Apold and Daia having fewer; Table 5.2a) and we must remember that it is not exactly the same farmers interviewed every year. Statistically significant results are indicated with an *, but non-significant results still help us see a trend.

Table 5.2a An overview of the number of surveys per village per year. Darker greens indicate a higher number. There are no data for 2016. The number of surveys conducted in 2019 was comparable to 2018, but lower than 2015 and 2017.

Village	2013	2014	2015	2017	2018	2019
Apold	7	NA	13	17	NA	NA
Criț	11	5	29	21	17	15
Daia	NA	4	24	21	NA	NA
Mălâncrav	9	10	20	19	14	9
Meșendorf	6	6	29	22	16	14
Nou Săsesc	4	3	11	6	5	6
Richiș	5	7	18	11	12	11
Viscri	6	6	9	20	16	16

Across the whole landscape through time, irrespective of village (Table 5.2b):

- * The month of the first hay cut seems to be getting earlier. This averaged around July in 2013, gradually getting earlier to April in 2019. The month of the latest hay cut seems relatively stable, around August, but it was July in 2013.
- Livestock numbers were relatively low amongst the farmers interviewed in 2019, contributing to a general downward trend across cattle*, sheep, pigs*, and goats*. Future years' data will be very important towards understanding whether or not this is a true trend across the landscape, or an artefact of the farmers who partook in the survey.
    - In line with this, wolf and bear attacks may be increasing. This does not seem to be an artefact of the number of surveys (non-significant correlation between attacks and the number of surveys is -0.12)

These general trends through time can be distilled across the individual villages (Table 5.2c). The correlations have not been tested for significance because of inconsistencies in the data; they are, therefore, indicative only.

- The earliest month of the first hay cut getting earlier each year seems to be reflected in all villages, except Meşendorf and Nou Săsesc.
- Livestock
    - The only village in which there is a general increase in milk cattle is Viscri.
    - Beef cattle seem to be decreasing through the years across all farmers surveyed.
    - Lambs and ewes seem to be decreasing somewhat in all villages, except for Apold (ewes increasing; lambs decreasing; n.b. only three years of data), Nou Săsesc (ewes and lambs increasing), and Viscri (lambs stable; ewes increasing).
    - In Viscri, goats and horses/donkeys are increasing. Horses/donkeys are also increasing in Daia.
- The potential increase in wolf/bear attacks seems to be most prevalent in Apold, Daia, Meşendorf, Richiş, and Viscri. There might be a slight decrease in Nou Săsesc.

Conclusion

The data point to change, certainly. However, overall, more years of data are needed to identify the extent of intensification and where this is happening.

Table 5.2b Mean (average) farm survey results across all villages for each year. The correlations are coloured blue through to green (0 = white; blue = negative correlation [as year increases, measured value decreases]; green = positive). These correlations are mainly useful for quickly gauging the trend. There is not a lot of years of data, so there are few significant correlations; these are, however, indicated in yellow in the final column ($p < 0.05$). *Survey effort is not controlled for sum of wolf/bear attacks.

	2013	2014	2015	2017	2018	2019	Sum or mean	Correlation	p value
n interviews (sum)	41	48	153	137	80	71	**530**	**0.25**	**0.63**
n years farmed (mean)	22.5	19.2	1.0	21.8	24.5	26.8	**19.3**	**0.40**	**0.43**
Total area farmed (ha) (mean)	49.7	23.8	16.4	23.3	19.7	16.5	**24.9**	**-0.68**	**0.14**
Area of arable land (ha) (mean)	13.9	7.8	5.8	4.7	5.4	5.0	**7.1**	**-0.78**	**0.07**
Area of grassland for hay (ha) (mean)	17.0	18.0	8.2	8.2	8.4	9.4	**11.5**	**-0.76**	**0.08**
Month of first hay cut (mean of the mean)	7	6	6	6	6	6	**6.2**	**-0.62**	**0.19**
Month of first hay cut (earliest) (mean)	6	5	5	5	4	4	**4.8**	**-0.90**	**0.02**
Month of first hay cut (latest) (mean)	7	8	8	8	8	8	**7.8**	**0.62**	**0.19**
n Milk cattle (mean)	25.4	10.3	10.1	9.5	8.7	8.1	**12.0**	**-0.71**	**0.11**
n Beef cattle (mean)	4.3	8.1	3.3	0.1	0.8	0.4	**2.8**	**-0.81**	**0.05**
n Ewes in pendulation (mean)	119.9	119.8	52.0	51.2	45.2	23.7	**68.6**	**-0.90**	**0.01**
n Fattening lambs in pendulation (mean)	44.4	70.4	8.2	17.1	22.2	3.1	**27.6**	**-0.70**	**0.12**
n Pigs (mean)	4.5	5.4	4.9	2.9	2.8	3.1	**3.9**	**-0.85**	**0.03**
n Goats (mean)	17.8	20.6	12.4	6.5	4.5	1.4	**10.5**	**-0.96**	**0.00**
n Horses or donkeys (mean)	0.9	1.8	1.0	0.9	0.9	1.0	**1.1**	**-0.37**	**0.47**
n Wolf/bear attacks in last 12 months (sum)*	25	13	28	103	453	394	**1016**	**0.87**	**0.02**

Table 5.2c Summary statistics for each village, showing the sum (for number of interviews and wolf/bear attacks) or mean (everything else) in the top half of the table (darker green = higher number) and correlations between the variable and year in the bottom half (0 = white; blue = negative correlation [as year increases, measured value decreases]; green = positive). The date of first hay cut refers to the month (i.e. June = 6, etc).Additional data can be found in the Supporting Information (see §8). It is important to note that significance values are not provided, so the correlations should be used only as a quick way to assess the trends, not as evidence for a definite trend; this is due to the limitations in the data discussed above.

		Number of interviews	Number (n) years farmed	Total area farmed (ha)	Area of arable land (ha)	Area of grassland for hay (ha)	Date of first hay cut (mean)	Date of first hay cut (earliest)	Date of first hay cut (latest)	n Milk cattle	n Beef cattle	n Ewes in pen-dulation	n Fattening lambs in pen-dulation	n Pigs	n Goats	n Horses or donkeys	n Wolf / bear attacks in last 12 months
Sum or mean	**Apold**	37	17.5	16.0	6.2	9.3	6.7	6.0	8.0	8.8	0.6	65.2	15.9	4.5	6.4	0.9	19
	Criț	98	18.9	22.2	9.3	13.5	6.0	5.3	7.3	11.8	2.7	99.7	37.6	3.8	14.9	0.7	39
	Daia	49	15.5	17.0	5.4	9.7	6.3	5.7	7.3	15.5	2.4	249.3	110.4	6.5	36.8	1.0	13
	Mălâncrav	81	22.4	14.2	5.6	5.6	6.5	5.8	7.7	8.0	1.3	49.3	13.5	4.6	2.5	0.7	63
	Meșendorf	93	20.0	73.4	17.2	26.5	6.2	5.7	7.0	28.8	8.3	65.0	32.9	3.7	22.2	2.0	89
	Nou_Săsesc	35	15.8	27.3	10.2	15.0	5.7	5.7	6.2	12.8	3.9	26.7	14.9	2.4	0.0	0.5	9
	Richiș	64	20.5	8.8	3.2	3.8	5.5	5.2	6.5	3.0	0.9	50.3	13.9	4.3	0.5	1.1	10
	Viscri	73	18.8	10.8	1.5	8.5	6.3	6.2	7.0	7.4	0.8	40.0	17.6	3.1	0.3	1.2	774
	ALL YEARS	**530**	**18.7**	**23.7**	**7.3**	**11.5**	**6.1**	**5.7**	**7.1**	**12.0**	**2.6**	**80.7**	**32.1**	**4.1**	**10.5**	**1.0**	**1016**
Correlation with year	**Apold**	0.95	0.15	0.99	0.29	-0.20	0.19	-0.98	0.00	-0.16	-0.76	0.98	-0.48	-0.98	-0.80	-0.87	1.00
	Criț	0.29	0.26	-0.86	-0.78	-0.90	0.00	-0.65	0.16	-0.83	-0.84	-0.74	-0.75	-0.46	-0.69	-0.63	-0.03
	Daia	0.66	0.01	0.86	0.09	0.41	-0.76	-0.76	-0.19	-0.91	-0.34	-0.80	-0.72	-0.80	-0.76	0.94	0.88
	Mălâncrav	0.12	0.49	-0.12	-0.30	0.53	-0.31	-0.60	0.33	-0.67	-0.67	-0.88	-0.79	-0.71	-0.57	-0.94	0.31
	Meșendorf	0.35	0.31	-0.81	-0.66	-0.75	0.41	0.49	0.00	-0.66	-0.58	-0.52	-0.67	-0.40	-0.42	-0.60	0.59
	Nou_Săsesc	0.15	0.47	0.52	0.36	0.23	-0.21	-0.21	-0.67	0.44	-0.64	0.27	0.33	-0.69	NA	-0.71	-0.29
	Richiș	0.39	0.54	0.47	0.08	0.23	-0.51	-0.72	0.00	-0.61	-0.96	-0.46	-0.35	-0.49	-0.55	-0.46	0.61
	Viscri	0.87	0.44	0.83	-0.73	0.70	-0.82	-0.79	0.00	0.80	-0.48	0.27	-0.05	-0.36	0.86	0.92	0.82
	MEAN	0.47	0.33	0.23	-0.21	0.03	-0.25	-0.53	0.00	-0.33	-0.66	-0.23	-0.43	-0.61	-0.42	-0.29	0.49

5.3 Grassland plants

Stachys officinalis (Betony), near Criț. JJB.

The botany results are split into two sections. Firstly, species-level trends across each village and through time are assessed (Tables 5.3a,b); secondly, plot-level temporal biodiversity trends are reported (Table 5.3c). For the latter, only significant trends are noted, whilst for the former, the results table is given in full.

5.3.1 Species trends (village)

25 of the 31 indicator species (see §4.9) appear in this analysis. The following species do not yet have sufficiently consistent data for reliable correlation analyses: Yellow Pheasant's Eye (*Adonis vernalis*); Burning Bush (*Dictamnus albus*); Red Viper's Bugloss (*Echium maculatum*); Fringed Gentian (*Gentianopis ciliate*); Military Orchid (*Orchis militaris*); Hairy Violet (*Viola hirta*).

Sainfoin (*Onobrychis viciifolia*), a legume, is decreasing in Apold, Richiș, and perhaps also in Meșendorf, making it one of the species with the most widespread declines. However, it is increasing in Viscri (Table 5.3a). Wild Thyme (*Thymus glabrescens*) is increasing in Apold and probably decreasing in Daia, but Daia has not been visited since 2017. Other species doing well include: Charterhouse Pink (*Dianthus carthusianorum*) in Nou Săsesc and Richiș, White Dwarf-Broom (*Chamaecytisus albus*) and Lady's Bedstraw (*Galium verum*) in Richiș, and Greater Milkwort (*Polygala major*) is Viscri.

Multiple villages currently have no significant upward or downward trends for any species, but this is likely to change in the future as the dataset grows.

Table 5.3a Plant species that are **significantly and consistently** increasing/decreasing, as shown by a significant correlation in Table 5.3b. Plants with a high (> 0.6 or <-0.6) correlation but that are not significant are shown in orange text.

Village	Species consistently increasing	Species consistently decreasing
Apold	Wild Thyme (*Thymus glabrescens*) Strong correlation, but not sig: Wall Germander (*Teucrium chamaedrys*)	Sainfoin (*Onobrychis viciifolia*) Strong correlation, but not sig: Yellow Scabious (*Scabiosa ochroleuca*)] Charterhouse Pink (*Dianthus carthusiano-rum*) Betony (*Stachys officinalis*)
Criț	None Strong correlation, but not sig: Crown Vetch (*Coronilla verum*)	None Strong correlation, but not sig: Sainfoin (*Onobrychis viciifolia*)
Daia	None Strong correlation, but not sig: None	Greater Self-heal (*Prunella grandiflora*) Deptford Pink (*Dianthus armeria*) Strong correlation, but not sig: Betony (*Stachys officinalis*) Charterhouse Pink (*Dianthus carthusiano-rum*) Wild Thyme (*Thymus glabrescens*)
Mălâncrav	None Strong correlation, but not sig: Lady's Bedstraw (*Galium verum*) Wild Thyme (*Thymus glabrescens*)	Crown Vetch (Coronilla verum) Strong correlation, but not sig: Yellow Flax (*Linum flavum*)
Meșen-dorf	None Strong correlation, but not sig: Yellow Flax (*Linum flavum*) Greater Milkwort (*Polygala major*)	None Strong correlation, but not sig: Sainfoin (*Onobrychis viciifolia*)
Nou Săsesc	Charterhouse Pink (*Dianthus carthusiano-rum*) Strong correlation, but not sig: Greater Self-heal (*Prunella grandiflora*) Dorycnium (*Dorycnium pentaphyllum*)	None Strong correlation, but not sig: Squinancywort (*Asperula cynanchica*)
Richiș	White Dwarf-Broom (*Chamaecytisus albus*) Charterhouse Pink (*Dianthus carthusiano-rum*) Lady's Bedstraw (*Galium verum*) Strong correlation, but not sig: None	Sainfoin (*Onobrychis viciifolia*) Strong correlation, but not sig: Sword-leaved Fleabane (*Inula ensifolia*) Siberian Bellflower (*Campanula sibirica*)
Viscri	Sainfoin (*Onobrychis viciifolia*) Greater Milkwort (*Polygala major*) Strong correlation, but not sig: Betony (*Stachys officinalis*) Lady's Bedstraw (*Galium verum*)	None Strong correlation, but not sig: None

Table 5.3b Table across two pages. Correlations between the ranked abundance of a species and year. Statistically significant results are in bold and underlined; those that are not significant (the majority) should be treated as indicative only. The correlations are coloured blue through to green (0 = white; blue = negative correlation [as year increases, measured value decreases]; green = positive).

		Apold	Criț	Daia	Mălân crav	Meșe ndorf	Nou Săsesc	Richiș	Viscri
	Number of years surveyed →	**7**	**7**	**5**	**7**	**7**	**7**	**7**	**7**
Scientific name	**Common name**								
Anthyllis vulneraria	Kidney Vetch						0.40	-0.21	
Asperula cynanchica	Squinancywort	0.31	0.25	-0.30	0.57	0.46	-0.68	-0.29	0.36
Campanula sibirica	Siberian Bellflower	0.48		0.00	-0.20	0.25	-0.29	-0.61	0.10
Chamaecytisus albus	White Dwarf-Broom	0.10					0.47	**1.00**	
Coronilla verum	Crown Vetch	-0.36	0.64	0.00	**-0.86**	-0.14	-0.14	-0.50	-0.29
Dianthus armeria	Deptford Pink		-0.06	**-0.90**	-0.39	-0.04	0.11	0.36	0.32
Dianthus carthusianorum	Carterhouse Pink	-0.63	-0.18	-0.70	-0.14	0.14	**0.93**	**0.89**	-0.29
Dorycnium pentaphyllum	Dorycnium	0.28	-0.14	-0.40	0.39	0.43	0.68	-0.11	0.21
Galium verum	Lady's Bedstraw	-0.56	0.32	-0.30	0.75	0.07	0.57	**0.86**	0.61
Inula ensifolia	Swordleaved Fleabane	-0.25	0.00	-0.49	-0.20	0.29	-0.16	-0.64	-0.25
Jurinea mollis	Jurinea				-0.05		-0.49	0.10	
Linum flavum	Yellow Flax	-0.41	0.41		-0.61	0.61	0.10	-0.21	0.39
Linum hirsutum	Hairy Flax	0.20			0.20		0.13	0.06	
Onobrychis viciifolia	Sainfoin	**-0.83**	-0.64	-0.30	-0.36	-0.68	0.07	**-0.81**	**0.86**
Orchis tridentata	Threetoothed Orchid						-0.41		
Polygala major	Greater Milkwort		0.49	-0.30	0.21	0.61	0.54	0.29	**0.76**
Prunella grandiflora	Greater Self-heal	0.29	0.20	**-0.97**	-0.33	0.57	0.71	0.36	-0.24

Salvia nutans	Nodding Sage				0.20		-0.41	-0.41	
Scabiosa ochroleuca	Yellow Scabious	-0.67	-0.46	-0.20	0.11	-0.48	0.08	-0.53	-0.04
Scorzonera purpurea	Purple Viper's Grass							-0.20	
Stachys officinalis	Betony	-0.61	0.21	-0.70	0.29	-0.32	0.18	-0.21	0.67
Teucrium chamaedrys	Wall Germander	0.69	0.14		0.51		-0.18	-0.14	-0.05
Thymus glabrescens	Wild Thyme	**0.83**	0.39	-0.60	0.71	0.32	0.32	0.11	0.44
Trifolium montanum	Mountain Clover	-0.61	0.29	0.18	0.13	0.28	-0.36	0.18	
Veronica austriaca	Large Speedwell	-0.39	-0.11	-0.36	-0.41	0.18	-0.16	-0.19	-0.18

5.3.2 Biodiversity trends (plots)

Table 5.3c The number of plots in and around each village in which biodiversity (defined by four different metrics; see §4.7) is **significantly and consistently** increasing or decreasing. Whichever is highest out of increasing/decreasing is shaded: blue (decreasing); green (increasing); grey (no significant results); orange (equal number of significant plots). Each village has a comparable total number of plots. The original plot-level correlations are provided in the Supporting Information (see §8).

Village	Total species richness		Total abundance		Simpson Index		Shannon Index	
	↑	↓	↑	↓	↑	↓	↑	↓
Apold	1	1	2	0	0	1	0	2
Criț	0	0	1	0	0	0	0	0
Daia	0	3	0	1	0	3	0	4
Mălâncrav	0	0	1	0	0	0	0	0
Meșendorf	1	0	0	0	0	0	0	0
Nou Săsesc	0	0	1	0	1	1	1	0
Richiș	1	1	0	1	1	1	1	1
Viscri	2	0	1	0	1	1	1	1

Overall biodiversity results are mixed across the villages' plots, with most plots still showing no significant upward or downward trends for any biodiversity metrics. As with the species trends, the number of significant trends will assuredly grow with the size of the dataset.

However, a few patterns are emerging if we consider the number of plots showing upward or downward trends in each village (Table 5.3c). Species richness is significantly increasing for at least one plot in Apold, Meşendorf, Richiş, and Viscri, with equivalent decreases in both Apold and Richiş. Abundance is the metric with the most significant trends, and these are generally in an upward direction, with at least one plot in all villages but Daia and Richiş showing a significant increase in total plant abundance.

Apold and Daia are each showing some significant **decreases** in **Simpson and Shannon indices**, with one plot in Nou Săsesc increasing. A decrease in Simpson's Index suggests that a community is becoming less even; i.e. a few species might be dominating. Meanwhile, a **decrease** in **Shannon's Index** through time suggests a decrease in diversity.

5.4 Grassland butterflies

Papilio machaon (Swallowtail). JJB.

The butterfly results are split into two sections. Firstly, species-level trends across each village and through time are assessed (Tables 5.4a,b); secondly, plot-level temporal biodiversity trends are reported (Table 5.4c). For the latter, only significant trends are noted, whilst for the former, the results table is given in full.

5.4.1 Species trends (village)

Butterfly data are notoriously inconsistent through time, owing the natural fluctuations in their population relating to weather, for example. This explains the small number of significant correlations detected in the data thus far (Table 5.4a). More years of data will no doubt begin to reveal a greater number of significant trends.

However, a number of species are clearly in decline (e.g. a number of fritillaries) or increasing (e.g. identified and unidentified blues; dryad) across multiple villages. Monitoring these important pollinators can offer an early warning of change in these traditionally managed agricultural systems, and we may be beginning to see that. Indeed, a large number of species are showing strong (but not [yet] statistically significant) temporal trends, some increasing and others decreasing. Table 5.4b details all butterfly species' correlations, including those that are not statistically significant but can still provide useful indicative information regarding trends.

Table 5.4a Butterfly species that are **significantly and consistently** increasing/decreasing, as shown by a significant correlation in Table 5.4b. Those names with 'species' after the genus / family are unidentified to the species level.

Village	Species consistently increasing	Species consistently decreasing
Apold	Blue species Small White (*Pieris rapae*)	Map (*Araschnia levana*) Large skipper (*Ochlodes venatu*)
Criț	None	Twin Spot Fritillary (*Brenthis hecate*) Painted lady (*Synthia carduii*) Small heath (*Coenonympha pamphilus*)
Daia	Eastern Short Tailed Blue (*Everes decol-oratus*)	None
Mălâncrav	Blue species Dryad (*Minois dryas*) Small White (*Pieris rapae*) Meleager's Blue (*Polyommatus daphnis*)	Silver washed fritillary (*Argynnis paphia*)
Meșendorf	Blue species *Melitaea athalia* or *aurelia* or *britomartis*	Weaver's fritillary (*Boloria dia*) High brown fritillary (*Argynnis adipe*) Heath fritillary (*Mellicta athalia*)
Nou Săsesc	Blue species Large blue (*Maculinea arion*) Dryad (*Minois dryas*) Pallas Fritillary (*Argynnis laodice*)	Heath fritillary (Mellicta athalia)
Richiș	Fritillary species	None
Viscri	Blue species Silver Studded Blue (*Plebejus argus*) Eastern Short-tailed Blue (*Cupido decol-oratus*)	Marbled white (*Melanariga galathea*)

Table 5.4 Table across five pages. Correlations between the ranked abundance of a species and year. Statistically significant results are in bold and underlined; those that are not significant (the majority) should be treated as indicative only. The correlations are coloured blue through to green (0 = white; blue = negative correlation [as year increases, measured value decreases]; green = positive).

		Apold	Criț	Daia	Mălâncrav	Meșen-dorf	Nou Săsesc	Richiș	Viscri
Number of years surveyed →		6	5	4	6	6	6	6	6
Scientific name	**Common name**								
Blue sp	Blue sp	**0.83**	0.84		**0.83**	**0.83**	0.65	**0.83**	**0.83**
Copper sp	Copper sp				0.65			0.65	
Essex or Small Skipper	Essex or Small Skipper		0.65		0.19	0.42	0.19	0.76	0.19
Forester Moth sp	Forester Moth sp		-0.70			-0.65	-0.65	-0.65	
Fritillary sp	Fritillary sp	0.57	0.65		0.65	0.65	0.65	**0.83**	0.70
Heath sp	Heath sp			0.26		-0.13	-0.13	-0.13	-0.13
Small or Chestnut Heath	Small or Chestnut Heath					0.65	0.65	0.65	
Yellow sp	Yellow sp	0.65	0.65		0.65		0.65	0.65	0.65

Aphantopus hyperantus	Ringlet	0.20	0.53	0.80	0.77	0.66	0.71	0.54	0.26
Araschnia levana	Map	**-0.94**	-0.43		-0.65	0.06	0.07	-0.38	
Argynnis adipe	High brown fritillary	-0.77	-0.76	-0.40	-0.65	**-0.94**	-0.66	-0.60	-0.65
Argynnis aglaja	Dark Green Fritillary	-0.39	-0.78	0.40	0.13	-0.79	0.07		-0.39
Argynnis laodice	Pallas Fritillary			-0.26		0.39	**0.83**		
Argynnis niobe	Niobe Fritillary		-0.52			-0.06			
Argynnis pandora	Cardinal					-0.13			
Argynnis paphia	Silver washed fritillary	-0.49	-0.61	0.60	**-0.93**	-0.49	-0.45	0.42	-0.65
Aricia agestis	Brown Argus	-0.39	-0.43	-0.26	-0.70			0.39	-0.13
Artogeia rapae	Small white	-0.46	-0.61	0.60	-0.52	-0.70	-0.46	-0.65	-0.79
Autographa gamma	Silver Y	-0.65	-0.70	-0.77	-0.65	-0.65	-0.65	-0.65	-0.65
Boloria dia	Weaver's fritillary	0.34	-0.69	-0.67	0.00	**-0.94**	0.00	0.26	-0.25
Boloria euphrosyne	Pearl-bordered Fritillary								
Boloria selene	Small Pearl-Bordered Fritillary	-0.08		0.40	-0.09			0.65	
Brenthis daphne	Marbled Fritillary		-0.70			-0.34	-0.71	-0.74	
Brenthis hecate	Twin Spot Fritillary		**-0.98**	-0.77		-0.51	-0.54		
Brenthis ino	Lesser marbled fritillary		0.11			-0.32	0.13	-0.65	
Callophrys rubi	Green Hairstreak						0.34	0.13	
Carterocephalus palaemon	Chequered skipper						0.65	0.65	
Celastrina argiolus	Holly blue	0.13		0.77		-0.08	0.31	0.09	0.32
Chiasmia clathrata	Latticed Heath								
Clossiana euphrosyne	Pearl bordered fritillary				-0.65				
Coenonympha arcania	Pearly Heath	-0.39	-0.65			-0.37	-0.77	-0.45	
Coenonympha glycerion	Chestnut Heath	0.26	0.59	0.26	-0.20	0.20	-0.34	0.23	
Coenonympha pamphilus	Small heath	-0.60	**-0.91**	0.40	-0.60	-0.66	0.20	-0.37	-0.71
Colias chrysotheme	Lesser Clouded Yellow				0.65				
Colias crocea	Clouded yellow	-0.45		0.26	-0.13	-0.13	-0.70	-0.13	
Colias erate	Eastern Pale Clouded Yellow								0.65
Colias hyale	Pale clouded yellow	-0.59	-0.65	0.40	-0.51	-0.51	-0.13	-0.06	-0.59
Colias hyale or alfacariensis	Colias hyale or alfacariensis	-0.19	0.04	-0.26	0.08	0.34	0.19	0.19	0.17

Colias myrmidone	Danube clouded yellow					-0.39			
Cupido alcetas	Provençal short-tailed blue								0.65
Cupido argiades	Short Tailed Blue	-0.09	0.84	0.13	0.03	0.14	-0.26	0.26	0.59
Cupido decol-oratus	Eastern Short-tailed Blue	0.65	0.65		0.65	0.70	0.70	0.39	**0.83**
Cupido minimus	Little Blue				0.39	0.39	0.39	0.39	
Cupido osiris	Osiris Blue	0.42	0.30	0.60	-0.20	-0.65	0.39		-0.07
Cyaniris semiar-gus	Mazarine Blue					-0.32		0.65	
Ematurga atomaria	Common Heath				-0.65				
Erynnis tages	Dingy skipper	-0.49	-0.08	0.80	-0.26	0.42	0.76		-0.26
Euclidia glyphica	Burnet Compan-ion	-0.65	-0.70	-0.77	-0.65	-0.65		-0.65	-0.65
Euplagia quad-ripunctaria	Jersey Tiger								
Eurodryas aurinia	Marsh fritillary								
Everes decol-oratus	Eastern Short Tailed Blue	0.13		**1.00**	-0.06			-0.13	-0.17
Glaucopsyche alexis	Green underside blue					0.13	-0.19	-0.33	
Gonepteryx rhamni	Brimstone		-0.78	-0.26		-0.45	-0.13	-0.13	0.13
Hamearis lucina	Duke Of Burgundy Fritillary				-0.13	0.42	0.39		
Heodes vir-gaureae	Scarce copper				-0.65	-0.65	-0.34	-0.65	
Hesperia comma	Silver spotted skipper	0.17	0.03	-0.77	0.07	-0.65			
Heteropterus morpheus	Large Chequered Skipper				-0.13	-0.65	-0.39	0.09	
Hipparchia dryas	Dryad	-0.79	-0.80	0.00	-0.65	-0.25	-0.13		-0.45
Inachis io	Peacock		-0.65	-0.26		0.08	-0.45	-0.13	-0.65
Iolana iolas	Iolas blue	-0.39					0.13		
Iphiclides podalir-ius	Scarce swallowtail	-0.17	0.08	0.40	-0.45	0.39	0.19	-0.13	0.07
Issoria lathonia	Queen of Spain Fritillary						0.39	0.39	-0.39
Lasiommata me-gera	Wall Brown				-0.13			0.39	
Leptidea mersei	Fenton's wood white				0.65			-0.65	
Leptidea sinapis	Wood White	-0.17	-0.65	0.60	-0.25	-0.34	-0.25	-0.25	-0.06
Leptidea sinapis or juvernica	Leptidea sinapis or juvernica	0.68	0.43	-0.26	0.08	0.51	0.76	0.76	0.51
Limenitis camilla	White Admiral						-0.65		
Lyacaenidae	Lyacaenidae sp	0.06	0.11	0.67	0.06	0.06	0.06	0.06	-0.06
Lycaeides argy-rognomon	Reverdin's blue	-0.70	0.11	-0.77	-0.65		-0.65	-0.65	-0.45

Lycaeides idas	Idas blue		-0.70			-0.65	-0.65		
Lycaena alciphron	Purple Shot Copper							0.06	
Lycaena dispar	Large Copper	-0.49		0.67	0.13	0.13			
Lycaena dispar rutila	Large Copper	-0.06	0.38	-0.26	-0.39				
Lycaena phlaeas	Small Copper				-0.70		0.70		-0.45
Lycaena tityrus	Sooty Cooper	0.13	0.24	0.26	0.20	0.39	0.39	-0.13	0.39
Lycaena virgaureae	Scarce Copper						0.39	0.39	
Lysandra coridon	Chalk-Hill Blue	0.13			-0.76	-0.39			
Macroglossum stellatarum	Hummingbird hawk-moth								
Maculinea alcon	Alcon blue					0.39			
Maculinea arion	Large blue				0.34	0.59	**0.85**	0.32	
Maculinea telejus	Scarce Large Blue		0.11						
Maniola jurtina	Meadow brown	-0.60	-0.08	0.00	-0.60	-0.66	-0.60	-0.77	-0.66
Melanargia galathea	Marbled white	-0.65	-0.84	0.00	-0.14	-0.60	0.09	0.09	**-0.83**
Meleageria daphnis	Meleager's blue	-0.41		-0.77	-0.57	-0.57		-0.65	
Melitaea asteria	Little fritillary								
Melitaea athalia OR aurelia OR britomartis	Melitaea athalia or aurelia or britomartis	0.65			0.70	**0.83**	0.70	0.70	
Melitaea aurelia	Nickerls Fritillary			0.77	0.13	-0.39	-0.52	-0.52	
Melitaea britomartis	Assman's Fritillary					-0.65	-0.70	-0.13	
Melitaea didyma	Spotted fritillary	-0.06	0.04	0.67	0.13	0.54			-0.13
Melitaea phoebe	Knapweed fritillary	-0.06		0.77	-0.65				
Melitaea trivia	Lesser spotted fritillary						-0.13		
Mellicta athalia	Heath fritillary		-0.24	-0.26	0.13	**-0.83**	**-0.83**		
Minois dryas	Dryad	0.83	0.84		**0.83**	0.39	**0.83**	0.39	0.70
Neptis sappho	Common Glider	-0.41			0.26	0.25	0.39		
Nymphalis polychloros	Large Tortoiseshell							-0.13	
Ochlodes sylvanus	Large Skipper					0.39	0.70	0.70	
Ochlodes venatu	Large skipper	**-0.83**	-0.43	-0.13	-0.13	-0.68	-0.59	-0.19	
Papilio machaon	Swallowtail	0.39	-0.11	0.26	-0.06	-0.32	0.45	0.08	0.13
Phengaris alcon	Alcon Blue	0.39				-0.06		0.13	
Pieris brassicae	Large white	-0.19	-0.43		0.19	0.39	0.65	0.06	0.13
Pieris napi	Green-Veined White		0.11		0.13	-0.39	-0.19	-0.26	
Pieris rapae	Small White	**0.83**			**0.83**	0.39	0.39	0.70	0.39
Plebejus argus	Silver Studded Blue	-0.71	0.84	0.80	0.14	-0.20	-0.71	-0.54	**0.89**

Plebejus idas OR argyrognomon	Plebejus idas or argyrognomon	0.39	0.38		0.70		0.39	0.65	
Plebicula dorylas	Turquoise Blue	0.13							
Polygonia c album	Comma	0.68		-0.77		-0.13	-0.65		0.65
Polyomattus icarus	Common blue	-0.59	-0.24	0.60	-0.59	-0.17	-0.34	-0.17	-0.06
Polyommatus bellargus	Adonis Blue	-0.65			-0.65	-0.65		-0.45	
Polyommatus coridon	Chalk-hill Blue				0.39				
Polyommatus daphnis	Meleager's Blue	0.65			**0.83**	0.39	0.70	0.39	
Polyommatus icarus	Alcon large blue	0.17	0.13	-0.26	0.17	-0.06	0.51	0.17	0.51
Polyommatus thersites	Chapman's Blue	0.41	0.65	0.26	0.46		0.65	-0.06	0.57
Pontia daplidice	Bath white				-0.65				0.13
Pontia edusa	Eastern Bath White								
Pseudophilotes baton	Baton blue		0.11				-0.70		0.13
Pseudophilotes vicrama schiffermuelleri	Eastern Baton Blue ssp schiffermuelleri	0.39	0.65				0.39	0.39	0.39
Pyrgus carthami	Safflower skipper								-0.39
Pyrgus malvae	Grizzled skipper		0.40	0.13	-0.13			0.39	-0.13
Pyrgus sylvestris	Small skipper	0.13	-0.43	0.20	-0.06	-0.33	-0.39	-0.17	-0.17
Satyrium acaciae	Sloe Hairstreak							0.65	
Synthia carduii	Painted lady	-0.45	**-0.92**	-0.67	-0.06	-0.65	-0.70	-0.68	-0.70
Thecla betulae	Brown Hairstreak				-0.39				
Thymelicus lineola	Essex Skipper		-0.76	-0.40	-0.70	-0.49	-0.37	0.66	-0.77
Thymelicus sylvestris	Small Skipper		0.65		0.65	0.70	0.70	0.70	0.65
Vaness atlanta	Red admiral	-0.33	0.11		-0.06	0.32	-0.42	-0.49	-0.19
Vanessa cardui	Painted Lady	0.65	0.65		0.65	0.65	0.65	0.65	0.65
Zygaena carniolica	Crepuscular burnet		-0.70			-0.65	-0.65	-0.65	
Zygaena filipendulae	Six-spot Burnet		-0.70	-0.77		-0.65	-0.65	-0.65	
Zygaena loti	Slender Scotch Burnet						-0.65		
Zygaena purpuralis	Transparent Burnet					-0.65	-0.65	-0.65	
Zygaena trifolii	Five-spot Burnet					-0.65	-0.65		

5.4.2 Biodiversity trends (plots)

Table 5.5d The number of plots in and around each village in which biodiversity (defined by four different metrics; see §4.7) is **significantly and consistently** increasing or decreasing. Whichever is highest out of increasing/decreasing is shaded: blue (decreasing); green (increasing); grey (no significant results); orange (equal number of significant plots). Each village has a comparable total number of plots. The original plot-level correlations are provided in the Supporting Information (see §8).

Village	Total species richness		Total abundance		Simpson Index		Shannon Index	
	↑	↓	↑	↓	↑	↓	↑	↓
Apold	1	1	2	0	0	1	0	2
Criț	0	0	1	0	0	0	0	0
Daia	0	3	0	1	0	3	0	4
Mălâncrav	0	0	1	0	0	0	0	0
Meșendorf	1	0	0	0	0	0	0	0
Nou Săsesc	0	0	1	0	1	1	1	0
Richiș	1	1	0	1	1	1	1	1
Viscri	2	0	1	0	1	1	1	1

Finer-scale trends at the plot-scale further demonstrate the complexity in the butterfly data, but there are some plots that are showing consistent increases and decreases in selected biodiversity metrics (Table 5.5d). Daia seems to be experiencing the most consistent declines in diversity across all metrics in multiple plots. This is the case when studying the significant trends (Table 5.5d) and non-significant trends (see Supporting Information). in biodiversity. It is worth noting, however, that Daia has only been studied in 2014, 2015, 2016, and 2017, so the data have not been updated for the 2019 (or indeed 2018) field season.

Simpson index is significantly **decreasing** through time for more plots than it is increasing for across Apold and Daia. A decrease in Simpson's Index suggests that a community is becoming less even; i.e. a few species might be dominating.

5.5 Birds: Point counts (BPC)

The BPC results are split into two sections. Firstly, species-level trends across each village and through time are assessed (Tables 5.5a,b,c); secondly, plot-level temporal biodiversity trends are reported (Table 5.5d). For the latter, only significant trends are noted, whilst for the former, the results table is given in full.

5.5.1 Species trends (village)

Temporal trends are becoming clear for many bird species as the dataset grows (Table 5.5b). The following species are decreasing across multiple villages (see Table 5.5a): whinchat; stonechat; linnet; hoopoe; and tree pipet. Table 5.5b suggests that many more species are also in decline, but we will need more years of data to identify statistically reliable trends.

Meanwhile, white storks, barn swallows, woodlarks, and yellow wagtails are increasing through time across multiple villages (Table 5.5a). Again, with others likely increasing (Table 5.5b).

Table(s) 5.5a Specially designated species (BirdLife grassland and/or PECBMS farmland species) that are **significantly and consistently** increasing/decreasing, as shown by a significant correlation in Table 5.5b.

Village	Species consistently increasing	Species consistently decreasing
Apold	White stork (*Ciconia ciconia*) Barn swallow (*Hirundo rustica*) Woodlark (*Lullula arborea*)	Whinchat (*Saxicola rubetra*)
Criț	Yellow wagtail (*Motacilla flava*)	Stonechat (*Saxicola torquatus*) Tawny pipit (*Anthus campestris*) Linnet (*Carduelis cannabina*) Yellowhammer (*Emberiza citrinella*) Whinchat (*Saxicola rubetra*)
Daia	Barn swallow (*Hirundo rustica*) White stork (*Ciconia ciconia*) Woodlark (*Lullula arborea*)	Whinchat (*Saxicola rubetra*) Hoopoe (*Upupa epops*) Turtle dove (*Streptopelia turtur*)
Mălâncrav	Stonechat (*Saxocola torquatus*) Grey heron (*Ardea cinerea*)	Woodlark (*Lullula arborea*) Hoopoe (*Upupa epops*) Tree pipit (*Anthus trivialis*)
Meșendorf	Woodlark (*Lullula arborea*) Black redstart (*Phoenicurus ochruros*) Bee-eater (*Merops apiaster*) Yellow wagtail (*Motacilla flava*)	Stonechat (*Saxocola torquatus*) Linnet (*Carduelis cannabina*)
Nou Săsesc	White stork (*Ciconia ciconia*)	Stonechat (*Saxocola torquatus*) Linnet (*Carduelis cannabina*) Tree pipit (*Anthus trivialis*)
Richiș	White stork (*Ciconia ciconia*) Tawny pipit (*Anthus campestris*)	Stonechat (*Saxocola torquatus*) Goldfinch (*Carduelis carduelis*)
Viscri	Lesser grey shrike (*Lanius minor*)	Stonechat (*Saxocola torquatus*)

Table 5.5b Table across three pages. Showing correlations between the ranked abundance of a species and year. Statistically significant results are in bold and underlined; those that are not significant (the majority) should be treated as indicative only. The correlations are coloured blue through to green (0 = white; blue = negative correlation [as year increases, measured value decreases]; green = positive). * "Designation" is how the table is principally ordered (then by scientific name) and shows whether that species is listed as: BirdLife International Grassland species (= 2); PECBMS farmland species (n = 1); both of those (n = 3); neither of those (n = 0).

Number of years surveyed →			7	6	4	7	7	7	7	7
		* Designation ↓	Apold	Criț	Daia	Mălâncrav	Meșendorf	Nou Săsesc	Richiș	Viscri
Skylark	*Alauda arvensis*	3		0.41	0.87		-0.46			-0.16
White stork	*Ciconia ciconia*	3	**0.84**	0.41	0.94		-0.48	**0.87**	**0.95**	0.36
Yellowhammer	*Emberiza citrinella*	3	-0.64	**-0.81**	-0.4	-0.72	-0.63	-0.75	-0.55	-0.64
Kestrel	*Falco tinnunculus*	3								0.66
Barn swallow	*Hirundo rustica*	3	**0.86**	0.32	0.8	0.29	0.04	-0.54	0.21	-0.04
Red-backed shrike	*Lanius collurio*	3	-0.43	-0.36	0.6	-0.43	-0.14	-0.68	-0.54	-0.39
Lesser grey shrike	*Lanius minor*	3								**0.99**
Whinchat	*Saxicola rubetra*	3	**-0.8**	**-0.64**	**-1**	-0.19	0	-0.62	-0.35	
Stonechat	*Saxicola torquatus*	3	-0.24	**-1**	0.5	-0.4	0.18	-0.35	0	0.1
Stonechat	*Saxocola torquatus*	3		**-1**		**1**	**-1**	**-1**	**-1**	**-1**
Starling	*Sturnus vulgaris*	3	-0.09	0.32	-0.2	-0.2	-0.54	-0.14	0.37	0.25
Common whitethroat	*Sylvia communis*	3	0.75	-0.41	-0.4		0.1	0	-0.51	0.47
Marsh warbler	*Acrocephalus palustris*	2	-0.5	-0.48		0.38		-0.3	-0.25	0
Tawny pipit	*Anthus campestris*	2		**-1**					**1**	
Tree pipit	*Anthus trivialis*	2	-0.19	-0.57		**-0.76**	0.05	**-0.83**	-0.38	0.75
Grey heron	*Ardea cinerea*	2	0.45			**1**				
Little owl	*Athene noctua*	2	0.39		-0.94					0.75
Goldfinch	*Carduelis carduelis*	2	-0.71	-0.4	-0.2	-0.32	-0.3	-0.75	**-0.79**	0.04
Raven	*Corvus corax*	2	-0.71	-0.18	0	-0.4	-0.5	-0.5	-0.57	0.14
Quail	*Coturnix coturnix*	2					-0.6			-0.38
Cuckoo	*Cuculus canorus*	2								-0.37
Robin	*Erithacus rubecula*	2	0.61			0.61	-0.69			0.2
Hobby	*Falco subbuteo*	2		0.62		0.66				-0.13
Great grey shrike	*Lanius excubitor*	2			-0.87					
River warbler	*Locustella fluviatilis*	2							-0.71	
Woodlark	*Lullula arborea*	2	**1**	-0.29	**1**	**-0.87**	**0.76**	-0.39	0.35	0.13
Thrush nightingale	*Luscinia luscinia*	2	-0.75							
Bee-eater	*Merops apiaster*	2	-0.46	0.27	0	-0.07	**0.87**	0.2	-0.07	-0.13
White wagtail	*Motacilla alba*	2	-0.25	-0.27	0.63	0.24	-0.32	-0.52	-0.59	0.41
Great tit	*Parus major*	2	-0.39	0.14	0.2	0.14	0.21	-0.54	-0.29	-0.46
House sparrow	*Passer domesticus*	2	0.07	-0.41	0.6	-0.43	-0.07	0.04	-0.14	-0.11
Black redstart	*Phoenicurus ochruros*	2	-0.59	0.8	-0.94	-0.29	**0.8**		0.06	-0.32

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Number of years surveyed →			7	6	4	7	7	7	7	7
* Designation ↓			Apold	Criț	Daia	Mălâncrav	Meșendorf	Nou Săsesc	Richiș	Viscri
Magpie	*Pica pica*	2	0.11	-0.36	0.2	0.09	0.48	-0.75	-0.32	-0.18
Blackbird	*Turdus merula*	2	0.06	0.05	-0.8	0.51	-0.57	0.05	-0.67	-0.24
Hoopoe	*Upupa epops*	2			-1	**-0.83**	-0.67		0.72	-0.75
Linnet	*Carduelis cannabina*	1	-0.53	**-0.93**	0	0	**-0.8**	-1	-0.21	-0.28
Yellow wagtail	*Motacilla flava*	1		**1**			**0.99**			-0.08
Tree sparrow	*Passer montanus*	1	-0.36	-0.09	-0.2	-0.07	-0.21	-0.57	-0.57	-0.57
Turtle dove	*Streptopelia turtur*	1	-0.35	-0.51	**-0.98**		-0.08		-0.59	0.2
Long-tailed tit	*Aegithalos caudatus*	0	0.09	-0.4	-0.8	0.04	0.4	**-0.98**	**1**	**1**
Mallard	*Anas platyrhynchos*	0	**-1**		**-1**					0.5
Lesser spotted eagle	*Aquila pomarina*	0		-0.6			-0.55			
Common buzzard	*Buteo buteo*	0	0.63	0.68	0.4	-0.69	-0.08	-0.32	-0.61	0.36
Treecreeper	*Certhia familiaris*	0		0.62			0.1			
Greenfinch	*Chloris chloris*	0	-0.13	-0.72	0.4	**-0.83**	-0.06	0.49	-0.57	-0.59
Hawfinch	*Coccothraustes coccothraustes*	0	-0.29	**0.81**	0.5	0.64	-0.36	**-0.89**	0.11	0
Feral pigeon	*Columba livia domest*	0	-0.2	0.18	-0.4	-0.39	0.72	-0.36	0.2	-0.32
Stock dove	*Columba oenas*	0	-0.24	-0.51	-0.8	0.2	-0.43	0.29	0.44	-0.73
Wood pigeon	*Columba palumbas*	0	**-0.93**	0	0	-0.32	-0.04	0.2	-0.52	-0.32
Hooded crow	*Corvus cornix*	0	**0.76**	-0.32	0.5		0.15	0.43	0.5	-0.68
Jackdaw	*Corvus monedula*	0								**-1**
Blue tit	*Cyanistes caeruleus*	0	-0.16	-0.36	**-1**	-0.57	-0.72	-0.45	-0.57	**0.97**
House martin	*Delichon urbica*	0	0.57	-0.09	-0.6	0	0.59	-0.13	-0.14	-0.48
Great spotted woodpecker	*Dendrocopos major*	0	0.13	0.33	0.4	0.54	-0.07	0.06	0.41	-0.38
Lesser spotted woodpecker	*Dendrocopos minor*	0		-0.6						
Middle spotted woodpecker	*Dendrocopus medius*	0		0.41		-0.61	-0.1		**-0.76**	0.38
Black woodpecker	*Dryocopus martius*	0	-0.41				0.13	-0.57	**-0.97**	
Corn bunting	*Emberiza calandra*	0								**0.94**
Collared flycatcher	*Ficedula albicollis*	0		-0.42		**-1**	**-0.87**	0		
Chaffinch	*Fringilla coelebs*	0	0.14	-0.47	-0.4	-0.46	**-0.81**	0.69	-0.62	-0.4
Jay	*Garrulus glandarius*	0	-0.14	-0.36	-0.6	0.46	0.05	-0.47	-0.41	0.64
Spotted flycatcher	*Muscicapa striata*	0	**-0.93**			0.73				
Golden oriole	*Oriolus oriolus*	0	0.57	-0.72	0.67	-0.38	0.04	-0.48	-0.19	0.28
Sparrow sp	*Passer sp*	0	**-1**				**-1**		**1**	
Coal tit	*Periparus ater*	0	**-0.94**	**1**		0.19		0.5	**1**	
Honey buzzard	*Pernis apivorus*	0	0.66	**-1**			**0.77**			**-0.87**

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	Number of years surveyed →		7	6	4	7	7	7	7	7
	* Designation ↓		Apold	Criț	Daia	Mălâncrav	Meșendorf	Nou Săsesc	Richiș	Viscri
Pheasant	*Phasianus colchicus*	0								-0.48
Chiffchaff	*Phylloscopus collybita*	0	**-0.81**	-0.2		**0.89**	0	-0.64	-0.2	-0.7
Wood warbler	*Phylloscopus sibilatrix*	0	0.36				-0.63			
Picidae sp	*Picidae*	0						**-1**		
Grey-headed wood-pecker	*Picus canus*	0		-0.3			-0.65	-0.7	**-0.78**	
Green woodpecker	*Picus viridis*	0	0.29	-0.73	0.77	-0.1	**0.83**	-0.51	0	0.49
Marsh tit	*Poecile palustris*	0	0.68	**0.95**	0.4	0.08	0.6	0.54	0.15	0.65
Nuthatch	*Sitta europaea*	0	-0.46	**-0.86**	0.26	-0.32	-0.55	-0.47	-0.4	0.1
Collared dove	*Streptopelia decaocto*	0	0.32	-0.63	-0.4	**-0.98**	0.38		-0.47	**-0.76**
Blackcap	*Sylvia atricapilla*	0			0.26	-0.67	-0.41	0.38		**0.79**
Lesser whitethroat	*Sylvia curruca*	0	-0.69		-0.94		0.5	-0.41	0.61	-0.08
Song thrush	*Turdus philomelos*	0	0.26	-0.62					0.39	0.37
Mistle thrush	*Turdus viscivorus*	0	**-0.76**				**1**			

Table 5.5c Species for which there is currently no identifiable trend across the years (i.e. these species do not appear in Table 5.5b). Ordered alphabetically by scientific name.

English name	Scientific name	English name	Scientific name
Goshawk	*Accipiter gentilis*	Lanius sp	*Lanius sp*
Sparrowhawk	*Accipiter nisus*	Common grasshopper warbler	*Locustella naevia*
Accipitriformes sp	*Accipitriformes sp*	Common nightingale	*Luscinia megarhynchos*
Great reed warbler	*Acrocephalus arundinaceus*	Grey wagtail	*Motacilla cinerea*
Sedge warbler	*Acrocephalus schoenobaenus*	Northern wheatear	*Oenanthe oenanthe*
Reed warbler	*Acrocephalus scirpaceus*	Scops owl	*Otus scops*
Alaudidae sp	*Alaudidae*	Paridae sp	*Paridae*
Common kingfisher	*Alcedo atthis*	Common redstart	*Phoenicurus phoenicurus*
Gadwall	*Anas strepera*	Phoenicurus sp	*Phoenicurus sp*
Meadow pipit	*Anthus pratensis*	Willow warbler	*Phylloscopus trochilus*
Swift	*Apus apus*	Picus sp	*Picus sp*
Purple heron	*Ardea Purpurea*	Bullfinch	*Pyrrhula pyrrhula*
Steppe buzzard	*Buteo buteo vulpinus*	Water rail	*Rallus aquaticus*
Buteo sp	*Buteo sp*	Goldcrest	*Regulus regulus*
Nightjar	*Caprimulgus europaeus*	Sand martin	*Riparia riparia*
Black stork	*Ciconia nigra*	Whinchat	*Saxicola rubetrus*
Harrier	*Circus circus*	Serin sp	*Serinus serinus*
Montagu's harrier	*Circus pygargus*	Tawny owl	*Strix aluco*
Columbidae sp	*Columbidae*	Garden warbler	*Sylvia borin*
Rook	*Corvus frugilegus*	Barred warbler	*Sylvia nisoria*
Crow sp	*Corvus sp*	Sylvia sp	*Sylvia sp*
Corncrake	*Crex crex*	Wood sandpiper	*Tringa glareola*
Crex sp	*Crex sp*	Wren	*Troglodytes troglodytes*
White-backed Woodpecker	*Dendrocopos leucotos*	Lapwing	*Vanellus vanellus*
Dendrocopos sp	*Dendrocopos sp*		
Red-breasted flycatcher	*Ficedula parva*		
Fringillidae sp	*Fringillidae*		
Eurasian coot	*Fulcia atra*		
Icterine warbler	*Hippolais icterina*		
Hirundinidae sp	*Hirundinidae*		
Olivacious warbler	*Iduna pallida*		
Wryneck	*Jynx torquilla*		

5.5.2 Biodiversity trends (plots)

Table 5.5d The number of plots in and around each village in which biodiversity (defined by four different metrics; see §4.7) is **significantly and consistently** increasing or decreasing. Whichever is highest out of increasing/decreasing is shaded: blue (decreasing); green (increasing); grey (no significant results); orange (equal number of significant plots). Each village has a comparable total number of plots. The original plot-level correlations are provided in the Supporting Information (see §8).

Village	Total species richness		Total abundance		Simpson Index		Shannon Index	
	↑	↓	↑	↓	↑	↓	↑	↓
Apold	6	3	2	2	5	1	1	2
Criț	6	1	9	2	5	3	7	3
Daia	1	3	2	4	7	4	3	4
Mălâncrav	12	1	6	1	3	1	5	1
Meșendorf	4	0	5	1	2	0	1	0
Nou Săsesc	6	0	5	0	3	1	9	1
Richiș	17	3	5	2	4	2	8	2
Viscri	2	0	2	1	6	1	2	2

Most plots do not yet have a sufficient quantity or consistency (in terms of the direction of the trend) in their data to obtain statistically significant results. However, for those that do, some patterns are emerging as to the direction of the trends for different biodiversity metrics (Table 5.5d).

There are more plots significantly increasing in **species richness and abundance** than those decreasing in those metrics. This is the case for all villages except Daia.

Simpson index is significantly increasing through time for more plots than it is decreasing for across all villages. An increase in Simpson's Index suggests that a community is becoming more even; i.e. similar abundance across all species, rather than a few species dominating. Meanwhile, an increase in **Shannon's Index** through time suggests an increase in diversity, which is supported by the results for a relatively large number of species richness and abundance increases.

As more data are obtained, more in depth analyses will be able to tell us about the community composition and exactly which species are causing these shifts in biodiversity. is also important to note that these data are just for the overall bird dataset and do not distil the results down just to look at BirdLife grassland species, for example.

5.6 Birds: Mist netting

Whilst the bird point count (BPC) data provide a consistent and robust methodology to study avian biodiversity change through time and across the landscape, these mist netting data offer vital insights into bird morphology, movement, and behaviour. These data are shared with Milvus to help with long-term monitoring at national and international levels (see §4.12). As the datasets grow, the combination of these two datasets (BPC and mist netting) will offer novel insights into avian biodiversity trends in this landscape, accounting for species traits, as well as their presence and abundance.

Bird mist netting data from 2019 are reported below (Table 5.6a). The historical data require additional sorting and will hopefully be incorporated into the next of these annual reports after some gaps are filled with regards to the exact locations of surveys and how many nets were used (and how long they were) to help control for this when analysing the data to make them comparable between and across the years.

When the number of surveys is controlled for, we had the highest number of individual birds (across all species) in Brădeni because of the high number of barn swallows. Criț had the lowest number of captures.

BirdLife International Grassland species are listed towards the top of Table 5.6a. Of those, species with particularly high numbers of individuals (for this year, across all locations combined; village with highest number in brackets) were: Barn Swallow (Brădeni), Red-backed Shrike (Criț and Mălâncrav), Common Whitethroat (Viscri), Marsh Warbler (Nou Săsesc and Mălâncrav), Great Tit (Angofa and Meșendorf), House Sparrow (Criț), Blackbird (Meșendorf), and Sedge Warbler (Brădeni).

As previously mentioned, no trends should be inferred from these data at this time. Data on morphology, recapture (of ringed birds), new captures, and other details are not contained within this report (or the Supporting Information) but these essential data have been passed onto the Milvus and, in time, will offer detailed insights into trends in our study area.

Table 5.6a Over four pages. All birds caught as part of the mist netting survey in 2019. Only the raw value for the number of observations per species is reported, so the number of surveys should be accounted for (noted at the top of the table). * "Designation" shows whether that species is listed as: BirdLife International Grassland species (= 2); PECBMS farmland species (n = 1); both of those (n = 3); neither of those (n = 0). Red shows a higher value; blue lower.

			Angofa	Apold	Brădeni	Bunești	Criț	Mălâncrav	Meșendorf	Nou Săsesc	Richiș	Viscri	TOTAL
Village →													
Number of netting mornings/afternoons →			7	7	4	3	9	9	8	10	9	11	**77**
Total number of Individuals →			142	88	307	4	136	237	210	161	75	241	**1601**
Number of Individuals adjusted for number of surveys →			20.29	12.57	76.75	1.33	15.11	26.33	26.25	16.10	8.33	21.91	**20.79**
Total number of Species →			23	29	15	1	25	33	30	24	17	34	**63**
Designation* ↓													
English name	**Scientific name**												
Yellowhammer	*Emberiza citrinella*	3		1			4		9	1	1	11	**27**
Barn Swallow	*Hirundo rustica*	3	4		153			43		5			**205**
Red-backed Shrike	*Lanius collurio*	3	20	13	1		41	23	6	9	1	8	**122**
Lesser Grey Shrike	*Lanius minor*	3					1					6	**7**
Whinchat	*Saxicola rubetra*	3							14			6	**20**
Stonechat	*Saxicola torquatus*	3		1	6			3	2			3	**15**
Starling	*Sturnus vulgaris*	3							2			4	**6**
Common White-throat	*Sylvia communis*	3	5	4			1	5	8	2	11	54	**90**
Great Reed Warbler	*Acrocephalus arundinaceus*	2		2	3			2		3			**10**
Marsh Warbler	*Acrocephalus palustris*	2	2	13	16		2	27		37	13	26	**136**

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Village →			Angofa	Apold	Brădeni	Bunești	Criț	Mălâncrav	Meșendorf	Nou Săsesc	Richiș	Viscri	TOTAL
Number of netting mornings/afternoons →			7	7	4	3	9	9	8	10	9	11	**77**
Sedge Warbler	*Acrocephalus schoenobaenus*	2		2	53								**55**
Tree Pipit	*Anthus trivialis*	2		1				1	1			8	**11**
Goldfinch	*Carduelis carduelis*	2							3			3	**6**
Cuckoo	*Cuculus canorus*	2										1	**1**
Robin	*Erithacus rubecula*	2	11	1			2	3	3	2			**22**
Wryneck	*Jynx torquilla*	2		1			2	1	1		3		**8**
Great Grey Shrike	*Lanius excubitor*	2										1	**1**
River warbler	*Locustella fluviatilis*	2	1	1			1			1			**4**
Thrush Nightingale	*Luscinia luscinia*	2	4	1	1		1					1	**8**
Bee-eater	*Merops apiaster*	2		7		4	1						**12**
White Wagtail	*Motacilla alba*	2		2	1			2		1			**6**
Great Tit	*Parus major*	2	28	13			10	16	21	14	12	13	**127**
House Sparrow	*Passer domesticus*	2		2			29	8	20	12		6	**77**
Black Redstart	*Phoenicurus ochruros*	2		3			1			2		1	**7**
Willow Warbler	*Phylloscopus trochilus*	2	6	1				1					**8**
Magpie	*Pica pica*	2										1	**1**
Water Rail	*Rallus aquaticus*	2						1					**1**
Sand Martin	*Riparia riparia*	2			2								**2**
Blackbird	*Turdus merula*	2	7	2			8	12	18	5	3	8	**63**
Hoopoe	*Upupa epops*	2									3		**3**
Yellow Wagtail	*Motacilla flava*	1			9							1	**10**

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			Village →	Angofa	Apold	Brădeni	Bunești	Criț	Mălâncrav	Meșendorf	Nou Săsesc	Richiș	Viscri	TOTAL
			Number of netting mornings/afternoons →	7	7	4	3	9	9	8	10	9	11	**77**
Tree Sparrow	*Passer montanus*	1						3	2	60	41	7	26	**139**
Sparrowhawk	*Accipiter nisus*	0		1										**1**
Reed Warbler	*Acrocephalus scirpaceus*	0			43									**43**
Kingfisher	*Alcedo atthis*	0		2	1			1						**4**
Long-eared Owl	*Asio otus*	0	2											**2**
Greenfinch	*Chloris chloris*	0							3	5	1		8	**17**
Hawfinch	*Coccothraustes coccothraustes*	0	7	2				2	28	1	6		1	**47**
Blue Tit	*Cyanistes caeruleus*	0	1	2					4	2		5	2	**16**
Great Spotted Woodpecker	*Dendrocopos major*	0	4	2				4	2	3	1		1	**17**
Lesser Spotted Woodpecker	*Dendrocopos minor*	0	2							3				**5**
Middle Spotted Woodpecker	*Dendrocopus medius*	0	2						1	3	2	1	2	**11**
Corn Bunting	*Emberiza calandra*	0								1				**1**
Reed Bunting	*Emberiza schoeniclus*	0			4									**4**
Collared Flycatcher	*Ficedula albicollis*	0					1	2					1	**4**
Jay	*Garrulus glandarius*	0						1						**1**
Icterine Warbler	*Hippolais icterina*	0											1	**1**
Savi's Warbler	*Locustella luscinioides*	0			10			1			1			**12**

→ *Continues on next page* →

			Village →	Angofa	Apold	Brădeni	Bunești	Criț	Mălâncrav	Meșendorf	Nou Săsesc	Richiș	Viscri	TOTAL
			Number of netting mornings/afternoons →	7	7	4	3	9	9	8	10	9	11	**77**
Common Nightingale	*Luscinia megarhynchos*	0										1		**1**
Northern Wheatear	*Oenanthe oenanthe*	0								1				**1**
Golden Oriole	*Oriolus oriolus*	0											3	**3**
Bearded Tit	*Panurus biarmicus*	0				4								**4**
Redstart	*Phoenicurus phoenicurus*	0						1						**1**
Chiffchaff	*Phylloscopus collybita*	0	4	2					2	1	3	2	2	**16**
Wood warbler	*Phylloscopus sibilatrix*	0											1	**1**
Grey-headed Woodpecker	*Picus canus*	0		1				1	1	1				**4**
Green Woodpecker	*Picus viridis*	0						1	1	2		1		**5**
Marsh Tit	*Poecile palustris*	0	10	3				6	11	11	1	5	3	**50**
Nuthatch	*Sitta europaea*	0	2					5	3	2				**12**
Blackcap	*Sylvia atricapilla*	0	11					4	13	2	7	5	4	**46**
Garden Warbler	*Sylvia borin*	0	3	1										**4**
Lesser Whitethroat	*Sylvia curruca*	0	4						2	2	1		19	**28**
Song Thrush	*Turdus philomelos*	0	2	1				4	11	2	3	1	5	**29**

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5.7 Bats

5.7.1 Introduction

With thanks to Dr Patrick Wright for writing the section. Dr Wright also led the bat fieldwork, collated the results, and carried out the analyses reported below.

Credit: Patrick Wright.

Bats occupy a wide range of ecological niches due to their species-specific adaptations which determine their foraging ecology and roosting behaviour. As predators at a high trophic level, they are sensitive to agricultural intensification, deforestation, development, and habitat fragmentation. They therefore provide good indicators of ecosystem health.

All bat species are protected in Europe under the EU Habitats Directive (2007), the Bern Convention on the Conservation of European Wildlife and Natural Habitats (1979), and the Bonn Convention on the Conservation of Migratory Species of Wild Animals (1979). All bats are listed under Annex IV of the EU Habitats Directive, which means that they require strict protection. An additional 14 species are listed under Annex II and require the designation of core sites for their protection (i.e. Special Areas for Conservation) and the implementation of conservation measures to maintain or restore the populations.

Romania is home to 32 bat species, 13 of which are listed under Annex II. Around 20 bat species, from 10 genera, are likely to occur in the Târnava Mare Natura 2000 region (Dietz *et al.*, 2009). As mentioned in several reviews of Romanian bat fauna, the majority of records of bats from Romania come from several rather intensively studied regions (Bihor, Banat, Dobrogea, and Danube delta); most of which were obtained by inspections of caves and roosts. This expedition therefore provides important data on bats from a lesser studied region of Romania – Târnava Mare – across a range of foraging habitats focussing around inhabited villages.

Commendable efforts have already been undertaken to safeguard bats as part of this network of protected areas in Romania. Most notably, a large EU funded project conducted by the Romanian Bat Protection Association titled '*Bat conservation in Pădurea Craiului, Bihor and Trascău Mountains*', which implemented safeguarding measures at numerous cave sites, known to contain bat roosts, to the northeast of Târnava Mare.

The Târnava Mare region is likely to have a high diversity of bats species due to the presence of cave systems, unpolluted water courses, large old-growth forests, and low levels of anthropogenic disturbance. However, increased levels of deforestation and agricultural intensification mean there is a need to monitor biodiversity trends in this region, which will allow for comparison with other parts of Europe that have already been exposed to much higher levels of anthropogenic landscape modification.

Despite Romania having valuable habitats that support much more diverse populations of bats than, for example, the UK; there are comparatively few monitoring or research initiatives underway. This further highlights the need for ongoing monitoring regimes to adequately inform policymakers of the biodiversity value of areas such as the Târnava Mare region.

The long-term aim of this project is to use bat diversity data, collected through monitoring bats in the Târnava Mare region, to inform stakeholders on a local and international level of the biological value of this region, and inform policy making in regard to biodiversity conservation. Additionally, the project aims to build capacity for future research endeavours and international collaboration, with the common goal of conserving bat populations. The primary objective is to include bats in the biodiversity monitoring programme of this region, so that the ecological importance of bats is recognised as a key aspect of the biological value of this Natura 2000 site.

5.7.2 Methods and Results

Trapping records

The results from the 2019 report are directly based on the framework established in 2018 developed to answer a range of research questions regarding bat distribution.

Bat surveys were conducted from June 17th to August 12th 2019. A total of 42 trapping surveys were conducted for a combined total of 184 hours and 19 minutes of trapping effort. One harp trap was used throughout all surveys, but the use of mist nets varied in size and numbers between surveys. The combined trapping effort using mist nets is calculated at 15,276 meters squared net hours (m^2nh). A total of 264 bats of 16 species were captured throughout the survey period (Figure 5.7a).

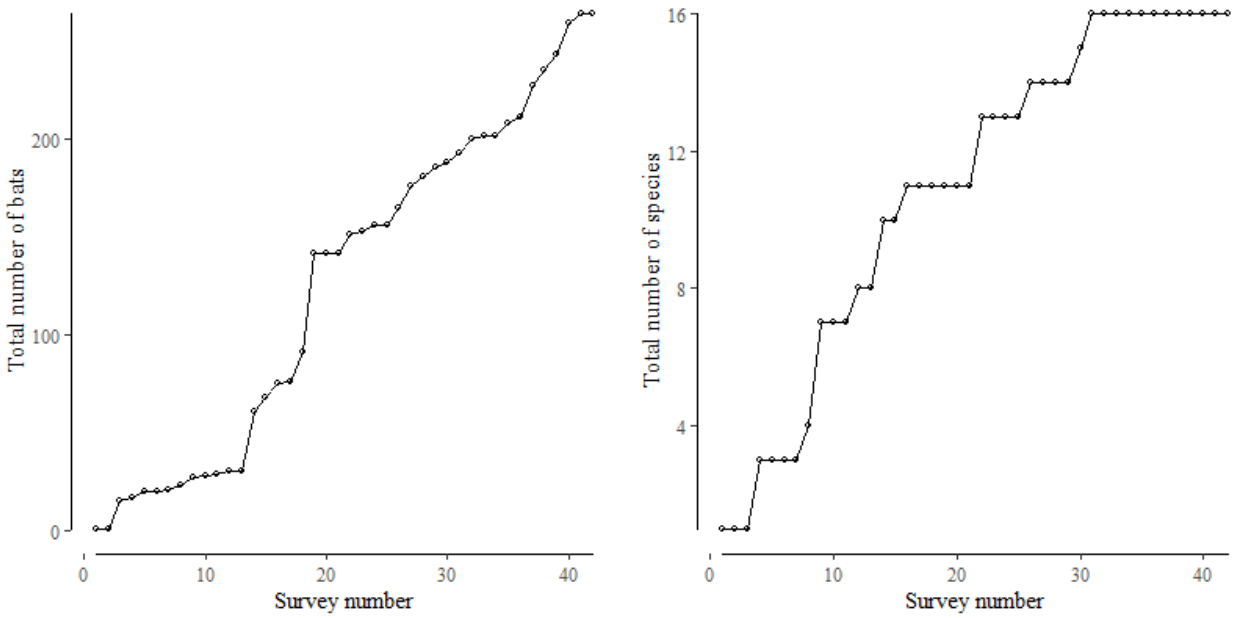

Figure 5.7a Number of bats and species accumulation throughout the 2019 expedition.

An average of 33 bats and 5.6 species were caught in each village catchment. The highest number of species was captured in the village of Nou Săsesc (8), while the lowest total was captured in Richiș (3). Viscri was the village where the most bats were captured (66), while only nine bats were caught in Meșendorf (**Error! Reference source not found.**).

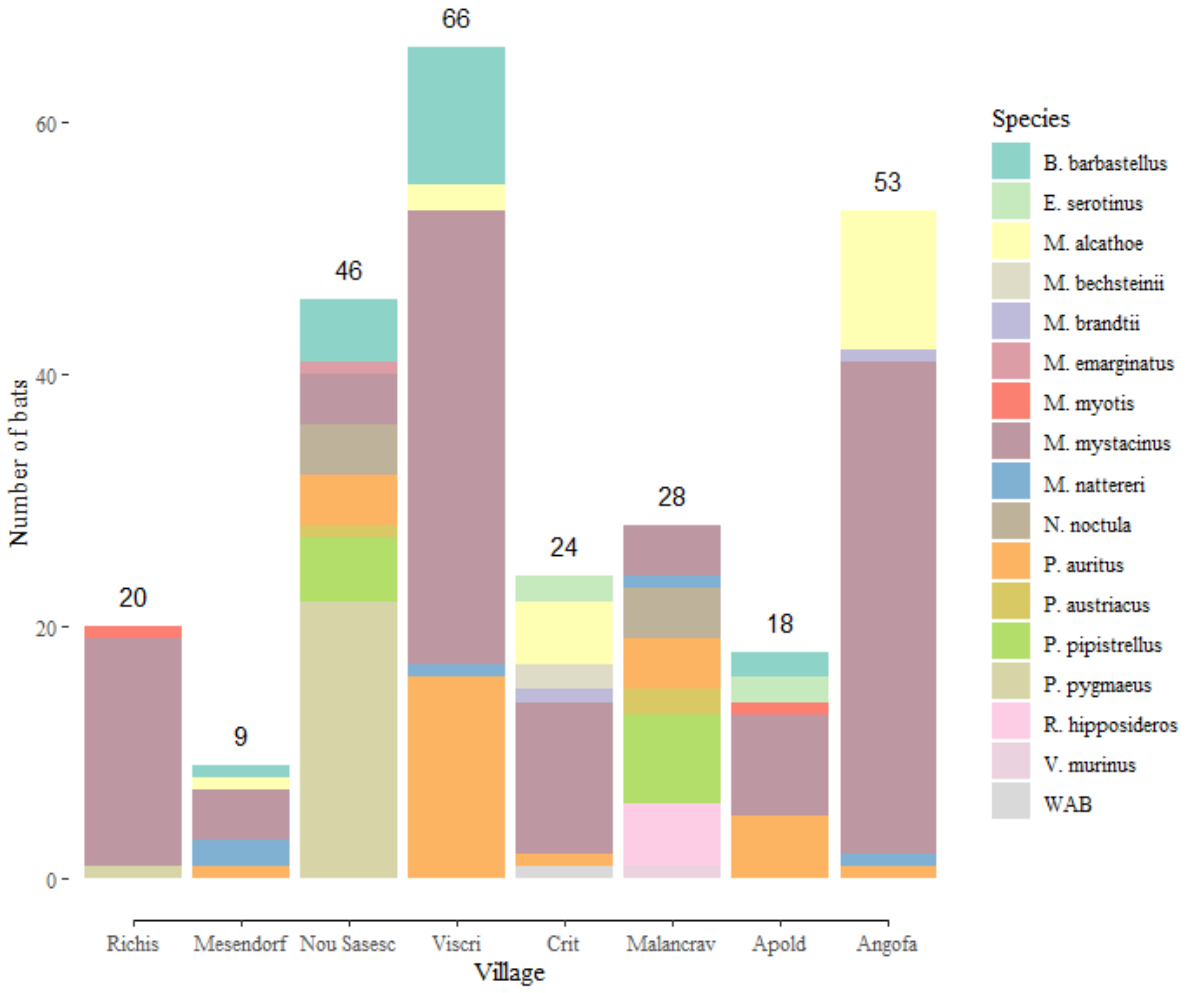

Figure 5.7b Number of bats of each species recorded at each village catchment through trapping (WAB – Whiskered, Alcathoe or Brandt's bat).

Myotis mystacinus (125) was the most recorded species from the trapping surveys, followed by *Plecotus auritus* (32) and *Pipistrellus pygmaeus* (23) (Figures 5.7b and 5.7c). Of the 16 species recorded, only *M. mystacinus* was recorded at each village catchment. A total of 10 species were captured less than 10 times over the surveying and 4 species (*Myotis bechsteinii, Myotis emarginatus, Rhinolophus hipposideros, Vespertilio murinus*) were only caught in a single village area (Figures 5.7b and 5.7c).

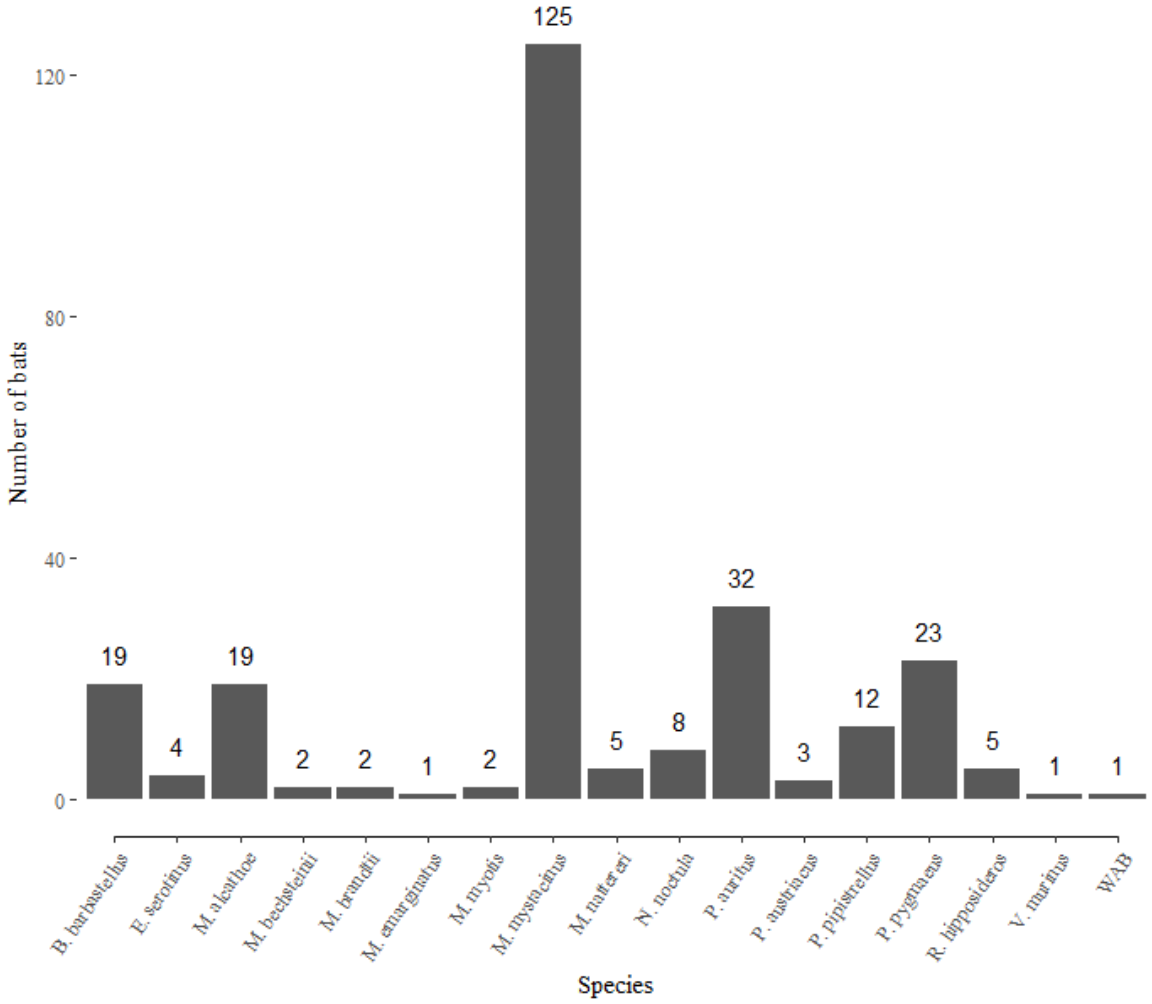

Figure 5.7c Total number of captures of each species throughout the 2019 survey period

Acoustic records

Acoustics were recorded using an AudioMoth and an Echo Meter 2. The Echo Meter recordings were taken at trapping survey locations, while the AudioMoth was deployed at 1-3 locations at each village. Sonograms of bat calls were processed using Kaleidoscope Pro (v.1.1.20, Wildlife Acoustics) with Romanian bat classifiers (v.1.0.5) and then manually verified.

The addition of acoustic data helped to detect an additional two species (*N. lasiopterus* and *N. leisleri*) that had not been captured throughout the whole survey period. Six species on average were detected with acoustic data alone in each village. *P. pygmaeus* was the species with the highest number of passes (993), followed by *N. noctula* (427) and *P. pipistrellus* (179) (Figure 5.7d).

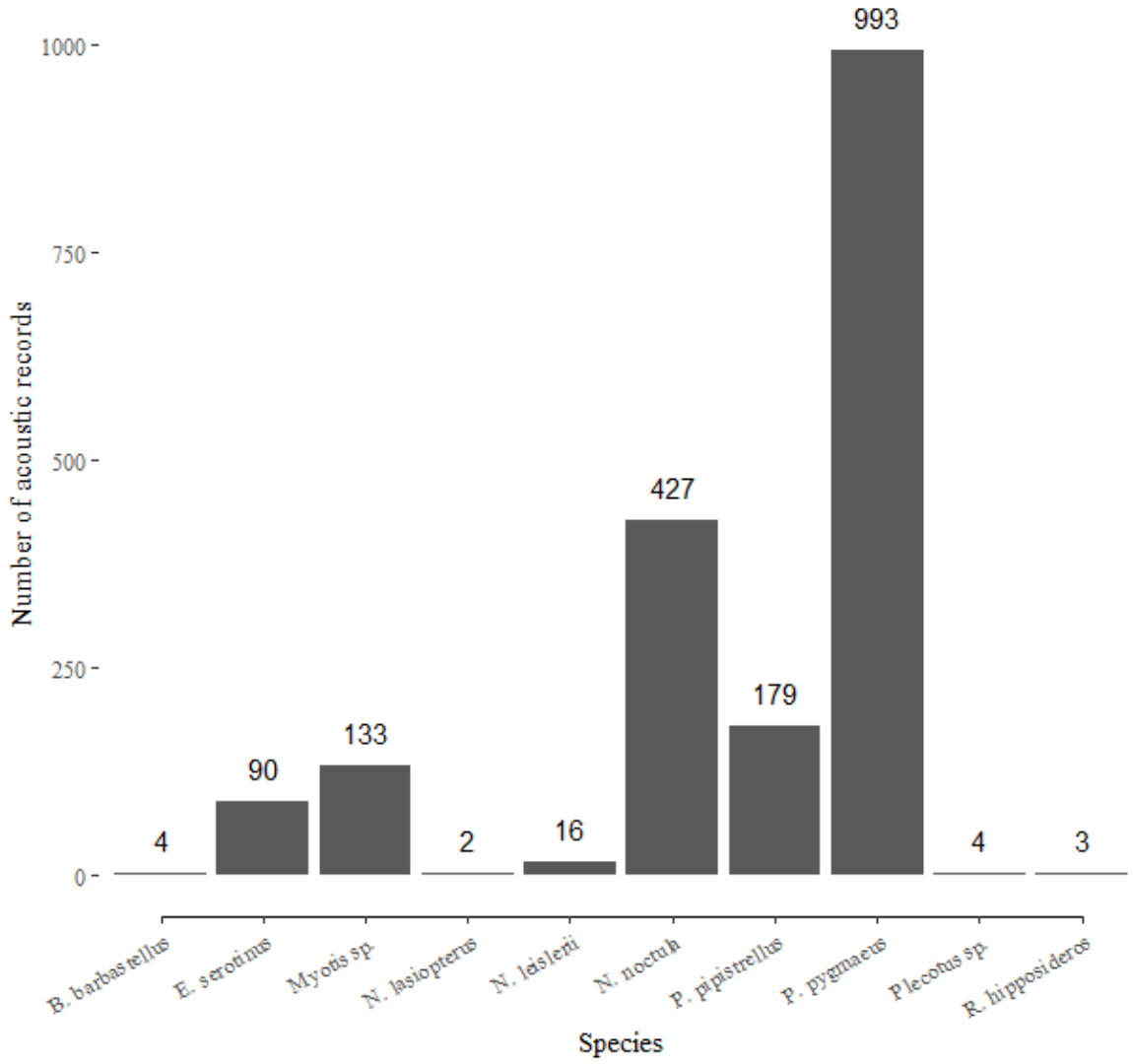

Figure 5.7d Total number of acoustic records of each species throughout the 2019 survey period

The high levels of activity of both *P. pygmaeus* and *N. noctula* were mainly explained by the placement of the static detector by a pond in Nou Săsesc where a lot of activity was recorded (Figure 5.7e). The use of detectors was particularly valuable in villages where very few species had been captured. For example, an additional 6 species were detected in Richiş while only three were captured and *E. serotinus* was recorded in an additional 4 villages (Figure 5.7d and Table 5.7a).

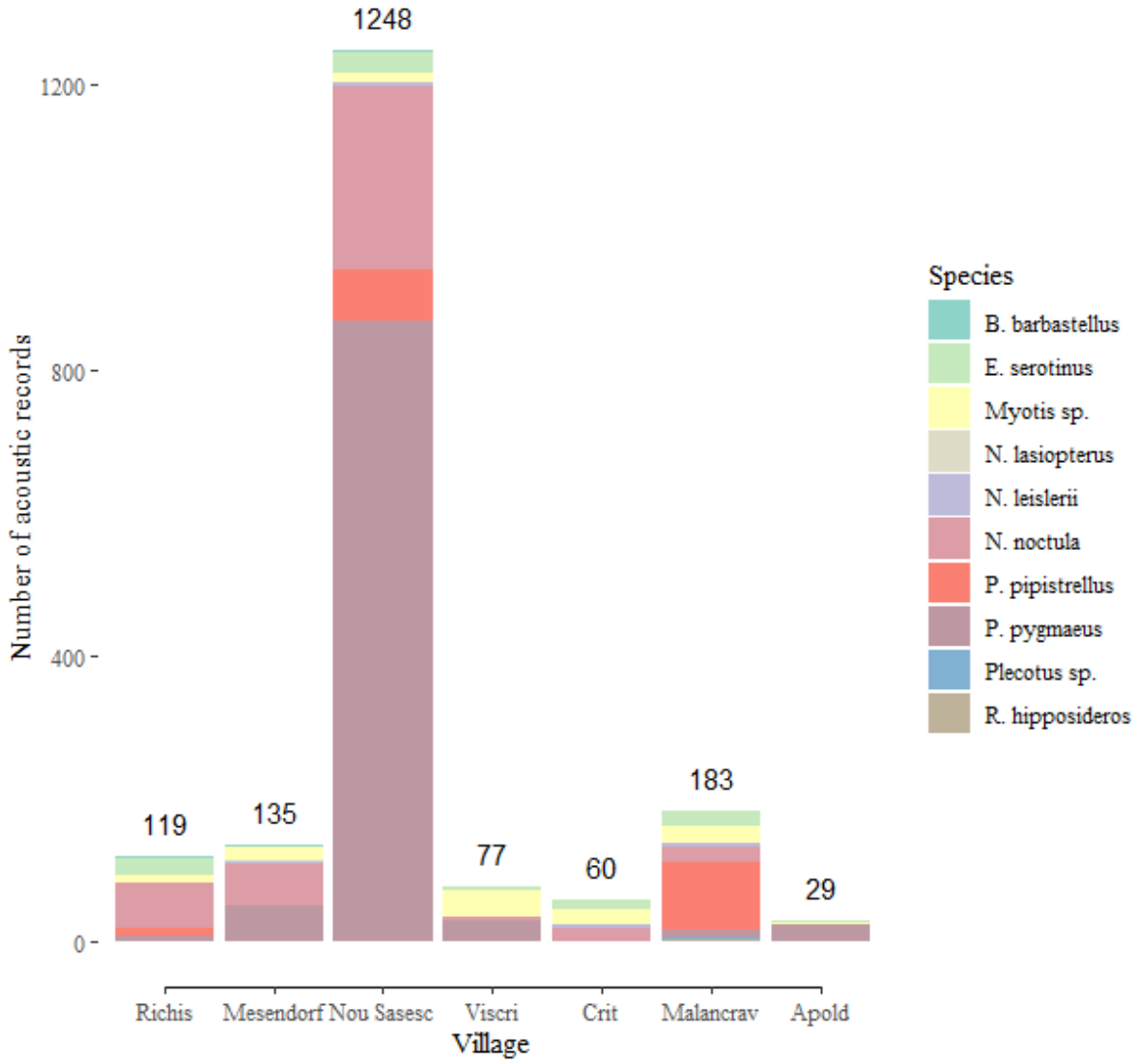

Figure 5.7e Number of acoustic recordings of each species recorded at each village catchment through trapping (all Myotis calls were grouped together).

Table 5.7a Summary of the number of species detected in each village for each surveying technique.

	Captures	Acoustic	Combined
Richiș	3	8	9
Meșendorf	5	6	9
Nou Săsesc	8	7	10
Viscri	5	4	8
Criț	7	4	9
Malencrav	8	8	12
Apold	5	5	7
Angofa	5	-	5

Roost surveys

Roost inspections were undertaken in all Saxon churches with the exception of Mălâncrav for which we did not have access (Table 5.7b). All churches showed evidence of bat activity (droppings, observed, caught). *P. auritus*, *M. Myotis*, *E. serotinus* and *M. mystacinus* were the most commonly observed species in the churches. The most significant colony observed remains the *M. myotis* maternity in Richiș where approximately 300 bats were observed in the church tower. Viscri, Apold and Nou Săsesc churches showed significant evidence of bats roosting in the church tower and building. In Meșendorf and Criț, however, very little evidence of bats was found. This information can be concerning in Criț as a *P. austriacus* roost was present in 2018.

Figure 5.7f Some of the *M. myotis* droppings in the Saxon church of Richiș. (Credit: Patrick Wright).

Table 5.7b Summary of the church inspections undertaken in each village

Village	Bats caught or observed	Droppings	Other comments
Richiș	Large *M. myotis* maternity roost (~300 bats) inside church tower	Large amounts of guano (**Error! Reference source not found.**) reported to lilieci.ro as they offer guano cleaning.	Possible disturbance by tourists regularly visiting during the breeding period
Meșendorf	*M. mystacinus* and *P. auritus* caught in churchyard	Small amounts of droppings in the church tower (no access to roof void).	Evidence of tawny owl and beech marten using the tower
Nou Săsesc	*P. auritus* and *M. emarginatus* caught in churchyard	Large and small droppings found in the tower. Very few inside the church (no access to roof void).	*P. auritus* likely to be roosting in the main church building in addition to the bell tower
Viscri	*P. auritus* caught inside church and *M. myotis* observed in tower	Significant amounts of droppings observed in the tower and roof void.	Warden was told that a colony of 78 bats (unknown species) was roosting in the church a few years ago. The number of species observed in 2019 was lower than in 2018. *P. auritus* colony may have also moved as 16 bats were seen emerging from a different nearby roost.
Criț	*P. auritus* caught inside church	Very few droppings observed	*P. austriacus* is known to roost inside the church and was observed in 2018, but there was no evidence of the species in 2019. Important flood lighting on the church which may cause disturbance to the bats.
Apold	*M. mystacinus* caught in churchyard; *P. auritus* & *E. serotinus* caught inside church & tower	Small amounts of droppings observed in throughout the tower and roof void	NA

5.7.3 Discussion

The overall abundance and diversity of species identified in 2019 was similar to 2018 as only *M. emarginatus* and *V. murinus* were not caught the previous year. Results from both years also confirm the presence in large numbers of *M. mystacinus* throughout the Târnava Mare region.

Interestingly, *M. alcathoe* was caught in large numbers in Angofa, but also in Criț, Viscri and Meșendorf. Such information is particularly valuable as the species was only recorded for the first time in Meșendorf and Mălâncrav in 2018. These records are important as the species was only discovered in 2001 and is classified as data deficient (DD) by the IUCN. In addition, the confirmed presence of five Annex II species (*B. barbastellus*, *M. bechsteinii*, *M. emarginatus*, *M. Myotis* & *R.*

hipposideros) throughout the surveying period and the presence of at least one species of conservation interest at each village catchment (Data Deficient or Annex II) confirms the importance of the Târnava Mare region for bats.

The addition of acoustic data, whilst being limited to the use of a single static detector and the ad-hoc use of an Echo Meter Pro, was very useful in confirming the presence of a number of species that were not caught in certain villages. For example, only three species were caught in Richiș, but an additional six species were identified with detectors. The possible presence of *N. lasiopterus* in the region is also of particular interest, because the species is sporadically distributed in Europe and classified as Data Deficient in Europe. The species is known to migrate long distances. Therefore, the bats could originate from neighbouring populations in the Carpathians.

It has been reported that a lot of church renovation work is going on in Romania. For example, two colonies were destroyed, in spite of good relations with priests. It appears that efforts by conservation charities, such as *lilieci.ro*, are ignored if funding for renovation is acquired. Such problems of abusive, ad-hoc building renovation and colony destruction appear to be accelerating in Romania.

Future directions

The 2019 Târnava Mare - Opwall bat expedition identified 16 species throughout the region. Five of the species present in the area are included in Annex II of the Habitats Directive and, therefore, require the designation of core sites for their protection. (Special Areas for Conservation – SAC). The project also provides several records of *M. alcathoe,* a species classified as DD under the IUCN Red Listing. The additional use of static detectors during the project helped to provide a better picture of the species diversity at each village catchment. Overall, these results provide essential information that will contribute towards the conservation of bats in this Natura 2000 site.

The bat surveys in their current form provide essential information that is currently lacking on the presence and distribution of bats in the Târnava Mare region. However, the amount of data collected is very much limited in comparison to other surveys and does not answer questions regarding farming practices. The additional use of static detectors can help fill these knowledge gaps as they can generate large amounts of data within a short period of time. With a clear set of aims and objectives, this data could provide information on the effect of different farming practices on bat diversity, activity and their role as ecosystem service providers.

As mentioned previously, the renovation of buildings, such as churches, can have a serious impact on bat populations. Operation Wallacea's presence in each village is limited to a single week. Therefore, it is very hard to deal with any conflicts in relation to bats in buildings. Instead, farm surveys could also target churches and include additional questions regarding the presence of

bats and whether they are causing any issues. This information could then be directly passed on to organisations, such as *lilieci.ro*, who have more time and capacity to deal with such issues.

Please note that the 2018 report (Kitching, 2018) can be accessed via *https://www.op-wall.com/uploads/2018/10/Opwall-Transylvania-Bat-Survey-Report-2018.pdf*.

5.8 Small mammals

We are in the process of compiling a research paper to report on these small mammal data in more detail (see §3.6). Therefore, simply the number of each species captured (controlled for by number of survey nights) is presented for each village and year (Table 5.8a).

In 2019, we surveyed each of the villages for small mammals for 4 to 6 nights. The Eurasian pygmy shrew (*Sorex minutes*) was captured for the first time in Criț and Mălâncrav.

Species with the highest rates of capture (capture rate ≥ 5 captures per night) in 2019 were:

- Angofa: striped field mouse, wood mouse, and field vole
- Apold: yellow-necked mouse, wood mouse, common vole
- Criț: Yellow-necked mouse, wood mouse
- Mălâncrav: yellow-necked mouse [slightly below 5 per night]
- Meşendorf: yellow -necked mouse
- Nou Săsesc: yellow -necked mouse, wood mouse
- Richiş: yellow -necked mouse, field vole
- Viscri: low capture rates across all species.

At our new field site, Angofa, five species were captured across five survey nights: striped field mouse, yellow-necked mouse, Apodemus species, wood mouse, European water vole, bicoloured shrew, edible dormouse, European harvest mouse, and field vole.

The yellow-necked mouse had the lowest captures in Viscri, but a higher value than previous years in this location.

The bicoloured shrew was only captured in Angofa and has only been spotted sporadically: 2017 in Apold and 2018 in Mălâncrav. The Eurasian pygmy shrew (*Sorex minutes*) has been spotted for the first time in 2019 (in both Criț and Mălâncrav).

The most frequently captured species across all years are: striped field mouse, yellow-necked mouse, wood mouse, and the common vole.

Table 5.8a Across two pages. Small mammal observations per village and year. The number of survey nights is shown. The values reported are controlled for according to the number of survey nights in that village and year (total observed divided by number of survey nights). Red shows a higher value; blue lower.

			Striped field mouse	Yellow-necked mouse	True rat / mouse sp.	Wood mouse	European water vole	Bicoloured shrew	Edible dormouse	European harvest mouse	Field vole	Common vole	Vole sp.	Bank vole	Common shrew	Eurasian pygmy shrew	Shrew sp.
Village	Year	N Survey nights	*Apodemus agrarius*	*Apodemus flavicollis*	*Apodemus sp.*	*Apodemus sylvatics*	*Arvicola terrestris*	*Crocidura leucodon*	*Glis glis*	*Micromys minutus*	*Microtus agrestis*	*Microtus arvalis*	*Microtus sp.*	*Myodes glareolus*	*Sorex araneus*	*Sorex minutes*	*Sorex sp.*
Angofa	**2019**	**5**	6.00	6.80		7.60		0.20			8.40						
Apold	**2016**	**4**	0.25	10.25		2.50						3.25	0.25				
	2017	**5**	1.00	16.40		0.20		0.20	0.20			14.00					
	2018	**5**		3.20		0.20			0.60								
	2019	**6**	1.33	9.17	1.67	5.50						5.50	0.17				
Criț	**2017**	**5**	9.40	20.40		1.80					0.40			1.00			
	2018	**6**	0.83	6.00		0.17					1.33	0.33		0.17			
	2019	**6**	4.17	10.50	1.83	8.00					1.00	2.83		0.50		0.17	
Daia	**2016**	**5**	1.20	4.20		0.60						2.60					
	2017	**5**	1.00	13.60		0.20	0.20			0.20	14.20						
Mălâncrav	**2016**	**5**	1.20	2.80	0.20							11.80					
	2017	**5**	1.00	16.60	0.40	2.00					0.20	0.20		0.60			
	2018	**6**		10.00	0.17	0.33		0.17			0.17				0.17		
	2019	**5**	1.20	4.60	0.80	3.20						0.60				0.20	

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			Striped field mouse	Yellow-necked mouse	True rat / mouse sp.	Wood mouse	European water vole	Bicoloured shrew	Edible dormouse	European harvest mouse	Field vole	Common vole	Vole sp.	Bank vole	Common shrew	Eurasian pygmy shrew	Shrew sp.
Village	**Year**	**N Survey nights**	*Apodemus agrarius*	*Apodemus flavicollis*	*Apodemus sp.*	*Apodemus sylvatics*	*Arvicola terrestris*	*Crocidura leucodon*	*Glis glis*	*Micromys minutus*	*Microtus agrestis*	*Microtus arvalis*	*Microtus sp.*	*Myodes glareolus*	*Sorex araneus*	*Sorex minutes*	*Sorex sp.*
Meșendorf	**2016**	**5**	1.80	4.40		1.40								0.20			
	2017	**4**	2.75	9.75		6.75				0.25	1.25	0.50	0.25	0.50			
	2018	**3**		0.67		1.00											
	2019	**6**		7.33	1.33	3.50											
Nou Săsesc	**2016**	**5**	1.00	0.60		1.20					0.40		0.20				
	2017	**4**	1.75	17.25		7.25						0.25		0.50			
	2018	**5**	0.20	5.20		2.80						0.20		1.00	0.20		
	2019	**5**	0.60	7.60		8.80					0.60						
Richiș	**2016**	**5**	3.40			0.80					6.00		5.20				
	2017	**5**	1.40	5.40	0.40	6.80								0.60			
	2018	**5**		0.80		1.60					0.60	3.20			0.60		
	2019	**5**	1.40	9.60	0.80				1.40		6.00			0.60			
Viscri	**2016**	**4**	2.75	0.25		0.50						10.50					0.25
	2017	**2**		1.50		0.50								0.50			
	2018	**4**	0.50	0.50							2.00	1.50		0.25			
	2019	**4**	0.75	2.75		0.50					0.25			0.25			

5.9 Large mammals: Camera trap

A capture from one of our camera trap videos in 2019.

There were 19 camera traps in use in 2019. Typically, 18 were placed in a gridded formation in the woodland uphill of the village, beyond the pastures. Fewer camera traps were placed in Angofa (n = 9) so that we could informally begin to gauge what was present before implementing the grid system in future years.

No temporal trends have been analysed in this report, in anticipation of additional data under the grid system and increased number of hours of recordings – and therefore increasingly reliable data – in future years.

The number of observations of several large mammal species across the years show a range of large mammal activity across all locations (Table 5.9a).

In Angofa, our new site, we obtained 854 hours of camera trap data, mainly observing roe deer, but also single observations for: wildcat, wild boar, and brown bear. We had two observations of red fox, and three of red squirrel.

Roe deer are the most frequently seen across all sites, with 2019's numbers typically being the highest of all years for most sites. More data are needed before we can determine whether this is in fact an upward trend.

Elsewhere for 2019, we recorded the first observations for:

- Apold: brown hare and red squirrel
- Criț: brown hare
- Nou Săsesc: wild boar (red foxes were seen again, having first been observed in 2018)

Other points of note for certain species:

- **No brown bears** were spotted in Richiș, having been seen for 2017 and 2018.
- The number of **wild boar** was highest ever recorded this year in any one location and this was in Mălâncrav. The second highest is for Richiș in 2018, with **no wild boar** observed in that location in 2019.
- **Red foxes** were not seen in Nou Săsesc, having been spotted every other year previously.
- **Wild cats** were seen in Angofa, Apold, Mălâncrav (first time), Meșendorf, Nou Săsesc, and Viscri (none were spotted last year, but were in 2016 and 2017).
    - None were seen in Criț or Richiș, having been seen for the past two years in those locations.

Based on these data, **Richiș might be seeing a decline in large mammals** more than any other location: the number of red foxes has declined in the past two years and no wildcats, wild boar, or brown bear were seen, having been seen in 2017 and 2018.

Table 5.9a Across three pages. Large mammal camera trap observations, estimated for a 24 hour period based on the number of observations and the amount of time the camera traps were recording. I.e. a value of 1 would be if 24 observations of a species were made in 24 hours. Red shows a higher value; blue lower. The original observation data and in-built calculations are provided in the Supporting Information (see §8).

			Roe deer	Red deer	Euro-pean wildcat	Brown hare	Beech marten	Pine marten	Martin species	Euro-pean badger	Stoat	Red squirrel	Wild boar	Brown bear	Red fox
Village	**Year**	**n Hours CTs were in-stalled for**	***Capre-olus capreo-lus***	***Cervus ela-phus***	***Felis sil-vestris sil-vestris***	***Lepus euro-paeus***	***Martes foina***	***Martes martes***	***Martes species***	***Meles meles***	***Mustel a er-minea***	***Sciurus vul-garis***	***Sus scrofa***	***Ursus Arctos***	***Vulpes vulpes***
Angofa	**2019**	**854**	1.01		0.03				0.06			0.03	0.08	0.03	0.06
Apold	**2014**	**233**	0.41												0.21
	2015	**409**	0.47	0.06						0.47			0.12	0.35	0.59
	2016	**724**	0.10							0.07			0.07		0.17
	2017	**863**	0.81											0.06	
	2018	**655**	0.22		0.04				0.04	0.04				0.18	0.04
	2019	**1646**	1.34		0.03	0.07			0.03			0.01	0.03		0.04
Criț	**2014**	**341**	0.21										0.07		
	2015	**190**	0.88					0.13		0.13					0.13
	2017	**930**	0.26	0.05	0.08					0.03			0.44	0.03	
	2018	**756**	0.19		0.03				0.06	0.10			0.19	0.13	0.32
	2019	**1622**	0.46	0.10		0.01			0.13	0.12			0.24		0.09
Daia	**2014**	**349**	0.14										0.07	0.07	
	2015	**469**	0.72	0.15			0.46			0.31				0.05	0.36
	2016	**1077**	0.13			0.02			0.02				0.09	0.02	0.02
	2017	**853**	1.24	0.14									0.20		0.06

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			Roe deer	Red deer	Euro-pean wildcat	Brown hare	Beech marten	Pine marten	Martin species	Euro-pean badger	Stoat	Red squirrel	Wild boar	Brown bear	Red fox
Village	**Year**	**n Hours CTs were in-stalled for**	***Capre-olus capreo-lus***	***Cervus ela-phus***	***Felis sil-vestris sil-vestris***	***Lepus euro-paeus***	***Martes foina***	***Martes martes***	***Martes species***	***Meles meles***	***Mustel a er-minea***	***Sciurus vul-garis***	***Sus scrofa***	***Ursus Arctos***	***Vulpes vulpes***
Mălâncr av	**2014**	**355**	0.47				0.07						0.20	0.07	
	2016	**952**	0.08	0.10				0.03						0.03	
	2017	**857**	0.42												0.06
	2018	**752**	0.22			0.03			0.03						0.13
	2019	**1668**	1.02		0.10				0.01	0.07		0.09	0.81	0.13	0.12
Meșen-dorf	**2014**	**587**	0.53			0.12			0.04				0.08	0.04	0.25
	2016	**1094**	0.68	0.02	0.02		0.02			0.13		0.09		0.02	0.09
	2017	**1044**	0.30		0.02					0.09			0.05	0.02	0.05
	2018	**763**	0.28							0.19					0.09
	2019	**1686**	0.97		0.03				0.01	0.06		0.01	0.04	0.03	0.03
Nou Săsesc	**2014**	**379**	0.32		0.25		0.06			0.06					0.13
	2016	**635**	0.04				0.11				0.04				0.04
	2017	**874**	0.36		0.03										0.16
	2018	**740**	0.52							0.03				0.03	0.06
	2019	**1686**	0.63		0.01		0.04		0.01	0.03			0.01	0.03	

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			Roe deer	Red deer	Euro-pean wildcat	Brown hare	Beech marten	Pine marten	Martin species	Euro-pean badger	Stoat	Red squirrel	Wild boar	Brown bear	Red fox
Village	**Year**	**n Hours CTs were in-stalled for**	***Capre-olus capreo-lus***	***Cervus ela-phus***	***Felis sil-vestris sil-vestris***	***Lepus euro-paeus***	***Martes foina***	***Martes martes***	***Martes species***	***Meles meles***	***Mustel a er-minea***	***Sciurus vul-garis***	***Sus scrofa***	***Ursus Arctos***	***Vulpes vulpes***
Richiș	**2014**	**451**	0.74			0.11			0.05	0.16					0.21
	2016	**334**	0.36				0.50								
	2017	**1104**	0.15		0.02		0.11			0.02		0.02	0.09	0.02	0.17
	2018	**871**	0.72	0.03	0.03					0.03			0.61	0.08	0.11
	2019	**1451**	0.33						0.02	0.02					0.02
Viscri	**2014**	**375**	0.58	0.13	0.06										0.06
	2016	**957**	0.48		0.03	0.03				0.03					0.20
	2017	**1037**	0.37		0.09								0.19	0.05	0.02
	2018	**750**	0.99	0.10		0.03				0.03				0.06	0.16
	2019	**1696**	1.08		0.01				0.23	0.16			0.23	0.01	0.11

5.10 Large mammals: Signs

Bear prints, with a bank card for scale. Angofa. JJB.

These large mammal data surveys are an important supplementary dataset to the camera trapping operation, but it is difficult to use them to reliably assess temporal trends. A simple overview of which species were observed in each year and in each village is provided below (Table 5.10a).

The only observation not shown in the table below is for red squirrels, which were detected in Criț in 2019. Elsewhere, we can see that roe deer were seen across all villages, and brown hares, martens, badgers, boar, bears, and red foxes in most or all villages. Wildcats, stoats, and pole cats were seldom detected under these surveys in 2019.

The routes in Angofa (new for 2019) may need to be modified in the future to get closer to the forest edge, but there was clear evidence of bears. Anecdotally, a farmer also spoke to us about recent bear attacks in this area.

Table 5.10a Large mammal species for which evidence has been found per village per year (1 and shaded indicates sign of activity). These data have not been controlled for by sampling effort and should be seen as informally supplementing the more robust camera trapping survey (see §4.16).

		Roe deer	Red deer	Deer species	European wildcat	Brown hare	Beech marten	Pine marten	Martin species	European badger	Stoat	Weasel	Polecat	Wild boar	Brown bear	Red fox
Village	**Year**	***Capreolus capreolus***	***Cervus elaphus***	***Deer species***	***Felis silvestris silvestris***	***Lepus europaeus***	***Martes foina***	***Martes martes***	***Martes species***	***Meles meles***	***Mustela erminea***	***Mustela nivalis***	***Mustela putorius***	***Sus scrofa***	***Ursus Arctos***	***Vulpes vulpes***
Angofa	2019	1													1	1
Apold	2014	1	1			1			1	1				1		1
	2016	1	1			1	1		1	1				1	1	1
	2017	1	1			1	1			1				1	1	1
	2018	1								1				1	1	1
	2019	1				1				1					1	
Criț	2014	1	1	1		1				1				1	1	1
	2017	1	1		1	1				1				1	1	1
	2018	1			1	1			1	1				1	1	1
	2019	1	1			1			1	1				1	1	1
Daia	2014	1	1						1	1				1	1	1
	2016	1	1			1	1			1				1	1	1
	2017	1	1		1			1		1				1	1	1
Mălâncrav	2014	1	1	1			1	1	1	1	1			1		1
	2016	1	1	1		1	1		1	1	1			1	1	1
	2017	1	1				1	1		1			1		1	
	2018	1				1			1	1			1			
	2019	1				1			1	1				1	1	1

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		Roe deer	Red deer	Deer species	European wildcat	Brown hare	Beech marten	Pine marten	Martin species	European badger	Stoat	Weasel	Polecat	Wild boar	Brown bear	Red fox
Village	**Year**	***Capreolus capreolus***	***Cervus elaphus***	***Deer species***	***Felis silvestris silvestris***	***Lepus europaeus***	***Martes foina***	***Martes martes***	***Martes species***	***Meles meles***	***Mustela erminea***	***Mustela nivalis***	***Mustela putorius***	***Sus scrofa***	***Ursus Arctos***	***Vulpes vulpes***
Meșendorf	2014	1	1	1		1			1	1	1			1	1	1
	2016	1	1			1	1	1		1	1			1	1	1
	2017	1	1		1	1	1	1		1				1	1	1
	2018	1			1	1			1	1				1	1	1
	2019	1	1						1	1				1	1	1
Nou Săsesc	2014	1	1							1				1		1
	2016	1	1				1			1	1			1	1	1
	2017	1	1				1			1					1	1
	2018	1							1	1				1	1	1
	2019	1	1			1			1	1				1	1	1
Richiș	2014	1	1				1			1				1		1
	2016	1	1							1		1	1		1	1
	2017	1	1				1			1				1		1
	2018	1				1		1	1	1				1	1	1
	2019	1	1						1	1						1
Viscri	2014	1	1			1			1					1		
	2016	1	1			1	1		1	1				1	1	1
	2017	1								1				1		1
	2018	1							1	1				1	1	1
	2019	1								1				1	1	1

6 FUTURE DIRECTIONS

Significant trends for many species (across multiple taxa) and locations, and in farming practices, are becoming clear and, undoubtedly, many more will reveal themselves as this fantastic long-term monitoring dataset grows. For examples, several plots across our study region were identified as showing significant increases or decreases in various biodiversity metrics across different taxonomic groups and through time. Meanwhile, individual species at each of our village locations are also showing patterns of significant increase or decrease through time. Farming practices may also be shifting slightly, as well as potentially an increasing number of conflicts between livestock (and the associated guard dogs) and large mammals.

Daia has been noted several times as showing significant decreases in multiple biodiversity metrics. However, we have not visited Daia since 2017. Updated surveys at this location would be particularly interesting, if this were logistically possible within the confines of the field season.

As well as continuing to collect these biodiversity and farming data, a key goal for the coming months is to substantially increase the amount and quality of spatial data associated with our study area. This means obtaining more GIS and remote sensing data. These data will help us better understand land cover and landscape configuration around each sampling location and, in turn, should help us understand changes in biodiversity at these locations. Such data will also be able to contribute to dissertation students' and researchers' projects.

The bat report, produced by our bat survey leader (Dr Patrick Wright), identified a need to better understand churches in the area, and how changes might be affecting bats. With this in mind, we hope to develop a new church questionnaire, which would operate in the same way as the farmer questionnaire: i.e. a local person with knowledge of the church would be identified and asked if they would be good enough to volunteer to answer some questions. Having such data would help us identify key factors that might be affecting bat biodiversity.

Data on pollinators in addition to butterflies would greatly enhance our understanding of grassland biodiversity. These data could be used to develop studies around plant-pollinator interactions, for example. We hope to incorporate surveys on bees in future years.

Finally, trait data will be collated from secondary sources on plants and birds. Such data will improve our understanding of why certain species might be changing more than others.

Overall, we will continue to work towards addressing the question of how biodiversity is changing and why, in this unique landscape.

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8 SUPPORTING INFORMATION (SI)

In the interest of keeping this report as short as possible, an appendix of **supporting information (SI)** has been made available online. If the link below does not work or you require something that is not present, please email *j.bailey@yorksj.ac.uk* (alternative: *josephjbailey@outlook.com*).

Please click here to access the files via DropBox.

There is an Excel Workbook in the 2019 folder (*Opwall_Transylvania_2019_Report_SI.xlsx*), containing multiple sheets. These sheets are referred to in the relevant Results sections and should be used alongside the summary results tables in this report.

Cichorium intybus (Common chicory), near Criț. JJB.

~ End of Report ~