Bats of the Târnava Mare region of Transylvania: a summary report from 2018

Report author: Thomas Kitching.

Data collection was undertaken under the supervision of Thomas Kitching and Dr Kim Wallis, whom designed the survey methodology for this programme.

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Executive summary

This report summarises the data gathered by Operation Wallacea's Transylvania project on bats during summer of 2018. The 2018 field season involved bat trapping, roost assessments and acoustic surveys for a period of seven weeks. The focus was to investigate and monitor the bat populations in the Târnava Mare Natura 2000 region.

Bats are an important aspect of mammalian diversity in Europe, and Romania has one of the largest and most diverse populations. Bats are high trophic level predators and therefore play an important ecological role, as well as being important biodiversity indicators.

22 bat species were identified across the survey period, 69% of all the species known to occur in Romania; including 5 species listed in annex II of the EU habitats directive (2007). These species require designation of Special Areas for Conservation (SACs) and therefore demonstrate the importance of conservation efforts in this region.

Several notable species are present here with different specialised habitat requirements, demonstrating the ecological importance of the area. The species richness of bats here is also an indicator of a diverse invertebrate population.

The Saxon fortified churches in each village provide important roosting habitat for bats, and many support a number of species. Efforts should be made to safeguard these roosts which are protected by European legislation.

It is recommended that future efforts to survey bats as part of this project follow the methods outlined in this report, to produce temporally comparable data that can be used for future research projects. Static acoustic detectors should be purchased by the project so that remote sensing can be incorporated into the survey methods.

It is also recommended that all future bat-related surveying be conducted in collaboration with the Centre for Bat Research and Conservation (CBRC) in Romania, to promote data sharing to better evaluate the populations of Romanian bats.

1. Introduction

1.1. Project Background

The Târnava Mare region of Transylvania is part of the EU Natura 2000 network, an area that is included as part of a network of European protected areas; designated to safeguard Europe's biodiversity. This important mosaic of habitats, located within the foothills of the Carpathian mountain range, was successfully promoted to this status in 2008. Operation Wallacea, have been working in conjunction with Fundatia Adept to provide biodiversity reports that guide their conservation initiatives in the region. Fundatia Adept is a Romanian based biodiversity conservation and rural development NGO that helped secure the areas protected status, Operation Wallacea (OpWall) is an international volunteer-based NGO that supports conservation research.

The overall goal of the OpWall Transylvania project is to monitor population trends in key taxonomic groups, and relate these to changing farming practices and landscape change within the locale of the Târnava Mare region. The project combines long-term wildlife monitoring with student projects, and training students in ecological survey methods to produce data that provide insight into biodiversity trends in this region, and recognise links between changing landscape use and biodiversity.

The annual operation has been ongoing since 2013, initially set up to monitor changing farming practices' impact on grassland species. In addition to interviewing farmers and local stakeholders, the operation has focussed on the following wildlife groups: butterflies, grassland plants, small mammals (Rodentia, Insectivora), large mammals and birds. Butterflies, plants, birds and small mammals all follow a survey protocol that is repeated annually.

Bat surveys have also been conducted since 2013, however survey types and sampling effort have been inconsistent, thereby not allowing for direct comparison between years of data collection.

1.1. Bats in Romania and the Târnava Mare site

Romania is home to around 90 species of terrestrial mammals, 32 of which are bats. Globally, bats make up around 20% of all mammal species, which demonstrates in relative terms how bats make a very large contribution to biodiversity in Romania.

According to Dietz *et al.* (2009), around 20 bat species, from 10 genera, are likely to occur in the Târnava Mare Natura 2000 region. 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 the Târnava Mare site. Although, 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, in a range of foraging habitats focussing around an inhabited village.

Bats are known to occupy a wide range of ecological niches due to their species-specific adaptations which determine their foraging ecology and roosting behaviour. They are known to occupy woodlands, farmland, wetlands and even urban areas. As high trophic level predators, they are sensitive to agricultural intensification, deforestation, development and habitat fragmentation; therefore, they can be used as indicators of ecosystem health. Insectivorous bats occupy high trophic levels and are consequently sensitive to the accumulation of pesticides and other toxins. Variation in their abundance can be attributed to changes in the populations of their invertebrate prey species. Moreover, it has been shown that agricultural expansion and increased usage of pesticides may have a reductive effect on bat populations. The Târnava Mare region is likely to have a high diversity of bats species due to the presence of cave systems, un-polluted water courses, large old-growth forested areas and low levels of anthropogenic disturbance. However, increased levels of deforestation and agricultural intensification means 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.

Bats are protected in Romania 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, some bat species are listed under annex II, which means that they require the designation of Special Areas of Conservation (SACs). Despite Romania having valuable habitats that support much more diverse

populations of bats than, for example, the UK; there is 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.

1.2. Information Gathered from Previous Expeditions

Bat surveys have been conducted since 2013 as part of the OpWall expeditions. These have mostly focussed on acoustic surveys using static and hand-held detectors, with some trapping surveys and roost surveys. These surveys highlighted a number of important roost sites, most of which were able to be re-evaluated as part of the 2018 surveys.

In total 19 species were identified through acoustic data across 8 village catchment areas. Although only a summary of these results is currently available, and precise data collection and analysis methods post-2014 are unknown. Due to specialised acoustic equipment being used in previous surveys that was no longer accessible, these survey methods could not be repeated in 2018.

1.3. Aims and Objectives

The long-term aim 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 regards 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 can be recognised as being a key aspect of the biological value of this Natura 2000 site.

The objective of this report is to provide framework of survey methods that can be repeated as part of the ongoing project to produce data that can be utilised to answer a range of research questions regarding bat distribution, diversity, morphology, population dynamics and behaviour.

1.4. Scope of this report

This report provides an overview of the information gathered as part of the 2018 bat surveys with OpWall. Seven village catchment areas within the Târnava Mare site were surveyed for bats between the dates of June 22nd and August 6th of 2018. The report gives a snapshot of bat species, habitat associations and relative abundance in the region as recorded in 2018. As these data are only collected from one year and follow a new protocol of survey methods, inferences cannot be made regarding population trends in comparison to data collected on bats in previous years.

Details of survey and analysis methods are available in this report; these methods should be followed as closely as possible in future to allow for comparative data between annual expeditions. Quantitative results are reported on the recorded species and roosts from each village catchment. The species present are then evaluated and discussed in relation to conservation issues and habitat quality of the area. Recommendations for research topics and collaboration are then presented for future development of the project.

2. Methods

2.1. Study site

The survey expedition took place across seven villages within the Târnava Mare region. This is located in southern Transylvania, Romania, between the historic cities of Sibiu, Sighişoara and Braşov. It comprises roughly 85000ha of land that has remained relatively unchanged for hundreds of years. The area is regarded as being one of Europe's last medieval landscapes, characterised by forested ridges and gullies, pasture and hay meadows on gentler slopes and terraces, and arable land and smaller meadows on the flat valley bottoms near villages. A detailed map of the site, made by Fundata Adept, is shown in figure 1.

Catchment areas were designated around each village within which to conduct fieldwork. Within each catchment lies a varied mosaic of habitats encompassing old-growth woodland, plantations, water-courses, wetlands, urban areas and grasslands. Trapping sites were limited by accessibility, but distributed within each village catchment so as to include at least one woodland site, one village centre/urban site and one site by water. In previous expeditions, eight village catchments were surveyed. However, due to inaccessibility at one site, Daia, this meant that only seven villages were surveyed this year. Village catchment areas and trapping sites from the 2018 expedition are displayed in figure 2.

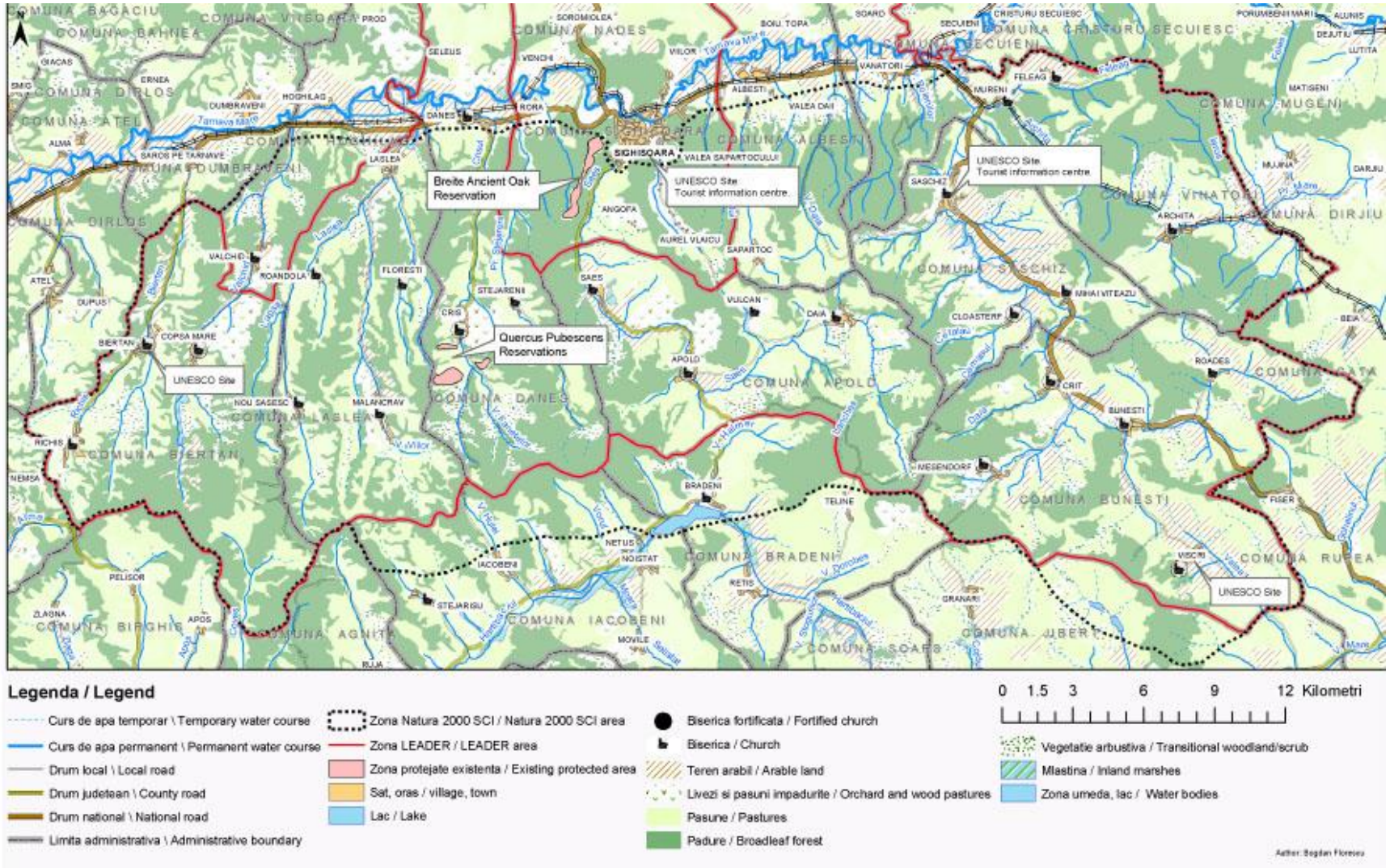

Figure 1. Târnava Mare Natura 2000 network area.

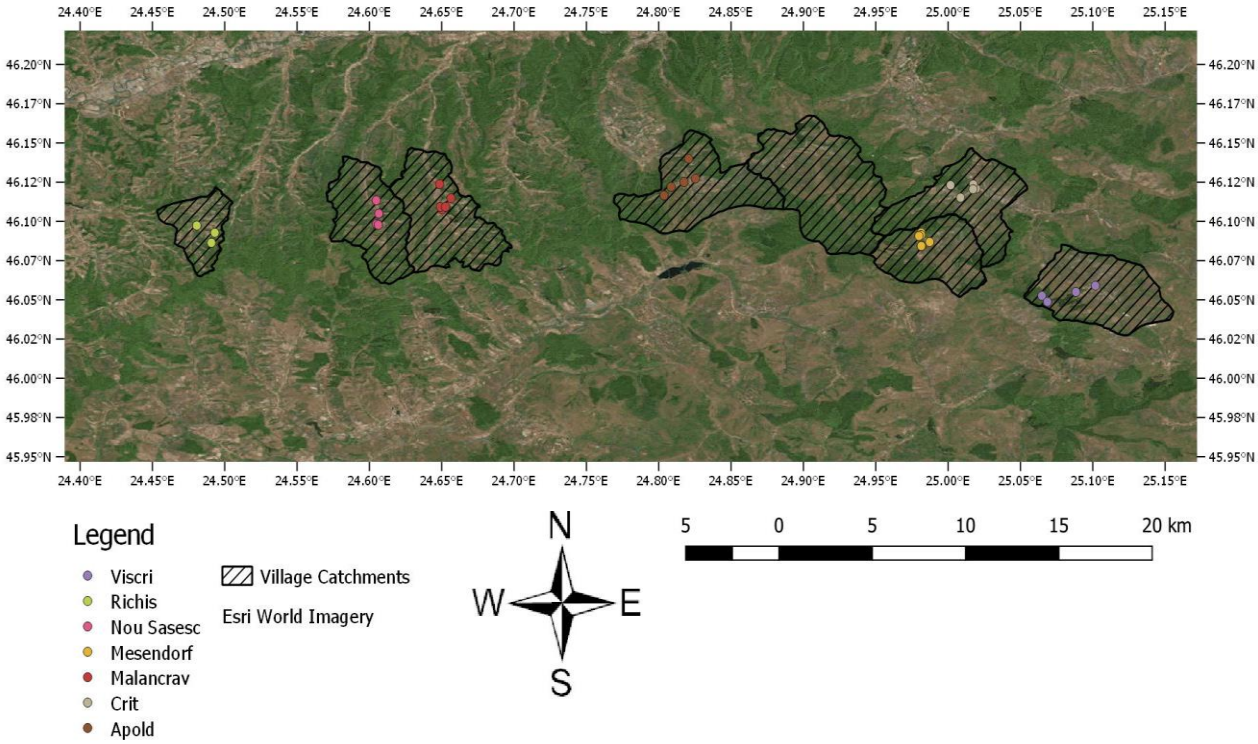

Figure 2. 2018 trapping sites and village catchment areas.

2.2. Survey methods

2.2.1 *Trapping surveys*

Trapping surveys were the main focus of data collection, this was so that bats could be identified to species level with a high degree of certainty not possible through acoustic surveys, and a greater variety of data could be collected. Trapping allowed for the collection of information regarding bat population dynamics; age, sex, breeding status, and for the collection of biological samples which can later be used for molecular techniques and identification of cryptic species, where necessary. Trapping was also considered to be more beneficial for training volunteers, with several advantages over acoustic surveys. Bat morphology, safe practice and species identification could be explained in a more interactive way using these methods. A complete list of variables that describe the conditions and location of each trapping survey and a list of all the measurements and data taken from each capture is listed in Appendix A.

Trapping surveys were conducted using mist nets and a harp trap, always under the supervision of experienced surveyors who emphasized ethical and safe practice. Due to logistical constraints, surveys varied in their duration and trap usage, but these variables were always recorded. Sites selected for trapping were designated

to represent the habitat types present within each village catchment, these typically were at least one woodland, urban and riverine site. Within these habitats, traps were placed in areas thought to be optimal for catching bats i.e. in enclosed habitat or flyways, by water or by openings in windows or roof cavities.

Generally, surveys were initiated 30 minutes before sunset and lasted for a minimum duration of three hours, however surveys were often conducted throughout the duration of the night. Trapping effort was calculated based on the area of mist nets used and the duration for which they were open, recorded in hours of mist net meters squared. Trapping surveys were conducted a minimum of five nights per village. Emphasis was placed on bat welfare throughout, so in some cases bats were released early and not all measurements were taken.

2.2.2. *Habitat data*

For all types of data collection, GPS coordinates were taken. This will enable for the collation of various types of habitat and climate data to be retrieved from readily available online resources of raster data, such as spatio-temporal gradients of rainfall and temperature. It will also enable for the quantification of habitat patch size and connectivity. An anthropogenic disturbance variable was also included, quantified as distance to urban area, this was calculated by the distance from the data point to a ten meter buffer around where there is a source of artificial light. In this case, this was the street lights located in the villages.

For smaller-scale habitat data, variables of tree height, canopy cover and clutter were recorded, where applicable (see Appendix A). Survey-specific weather variables were also recorded. These consisted of cloud cover, temperature and wind speed as these were thought to be the variables most likely to affect bat activity.

2.2.3. *Acoustic surveys and analysis*

Acoustics were recorded using an Echo Meter touch 2 pro acoustic recording device (Echo Meter Touch 2 Pro, 2018), these recordings were usually taken at trapping surveys as a means to demonstrate to students the use of sonograms for surveying bats. Recordings were subsequently analysed to provide additional bat presence data, however these were not collected in any strategic fashion. The device was used to record bats in full time-expansion mode, using the auto-heterodyne feature to demonstrate to students how sonograms appear visually at which frequencies for specific species. The acoustic recordings are therefore spatially distributed in the same manner as the trapping sites, and therefore the habitat data collected from the trapping sites is relevant to the acoustic data.

Acoustic recordings were analysed using Kaleidoscope pro 5 software (Kaleidoscope Pro, 2018), whereby recordings were categorised using the in-built auto-identification software, which was trained with the species known to be present in Romania, and then accepted/rejected by individual inspection. Recordings were split into five second durations; each recording with an accepted species identification is represented as one count of that species. Variation in amplitude and accurate detectability between species vocalisations will also affect the count; some species have much louder and more distinctive calls, and are therefore much more likely to be recorded and successfully identified. Therefore, the count of recordings for each species does not represent the number of individuals of that species that are present, but provides a snapshot of the species present that may have not have been recorded through trapping alone.

Given the similarity between some bat species calls, some were grouped into categories of possibilities where species identification could not be 100% confirmed, additionally some bat calls were unidentifiable and were thus recorded as 'No ID'. The nature of the way acoustic surveys were conducted and analysed means that these data cannot be used as an accurate measure of habitat associations of relative abundance, and should only be used as an indicator of species presence.

2.2.3 *Roost inspection*

Bats are known to roost in a variety of locations such as caves, trees, crevices and building voids. Within the scope of the fieldwork conducted here, only known high-priority roosts were inspected. These are roosts with aggregations of high numbers of bats where there is potential for human-bat conflict. Within this criteria, roost surveys focussed on buildings, predominantly the fortified Saxon churches present in each village, as access to these was relatively easy and did not require the specialist skill and equipment required of surveying trees and caves. These are very old buildings, with multiple roost features such as large undisturbed roof voids with many crevices and thick, cracked stone walls. Many of these Saxon churches have been present since the 14th century.

Roosts were inspected for evidence of bats, such as guano and oil staining, as well as internal and emergence surveys for the presence of bats using visual inspection. Several bat roosts were inspected to assess their functionality, protection and which species were present. Photographs were taken and key roost features were assessed and recorded. Where possible, anecdotal evidence regarding the roosts were acquired from locals. Each roost surveyed this year is described in section 3 of this report.

2.2.4. *Biological samples*

Bio-samples were taken from captured bats to build capacity for future microbiological projects and species identification through DNA analysis. Faecal and parasite samples were the main focus of data collection in these areas.

Faecal samples were collected from the bats themselves when visibly fresh, these were stored in clearly labelled eppendorf tubes with 95% ethanol. All samples were then stored in a controlled temperature environment, such as a fridge.

Parasite samples were extracted from bats with visible ecto-parasites on their fur or wings. These were extracted carefully from the bats with tweezers and stored individually in clearly labelled eppendorf tubes with 95% ethanol.

2.3. Ethics and safe practice

As the survey work conducted here was in the presence of volunteers and involved handling protected species a code of ethics and safe practice was therefore adhered to.

Field conditions were often cold, wet and for long durations of time; therefore suitable measures must be taken to ensure the health of staff and volunteers. All trapping surveys were equipped with a form of shelter, either a tent canvas or portable gazebo, so that volunteers and equipment could be kept dry. Additionally, blankets and hot drinks were always brought to for the health and comfort of parties involved in surveys.

Bats were only every handled by persons with valid rabies vaccinations, and wearing protective gloves. Survey leaders were also made aware of current rabies risks and 'high risk' species, namely *Myotis daubentonii* and *Eptesicus serotinus*, which were strictly only ever handled by survey leaders. Usually all handling was conducted by the survey leaders, but on occasion research assistants were allowed to release calm bats, provided they were wearing gloves and had their vaccinations. Emphasis was placed on bat welfare throughout, and bats were only kept for a maximum of one hour in bags before release. Extractions from trapping equipment were only ever conducted by survey leaders. All active traps were checked at least every 10 minutes to ensure bats were not fatigued or becoming overly entangled in mist nets. Measurements were only be taken by trained professionals to ensure data consistency and safe handling.

3. Results

3.1. Overview

Bat surveys were conducted during the period between June 22nd and August 6th 2018. A total of 38 trapping surveys were conducted for a combined total of 218 hours and 12 minutes of trapping effort. One harp trap was used throughout all surveys, but the use of mist nets varied in size and number of nets between surveys. The combined trapping effort using mist nets is calculated at 17402 meters squared net hours (m^2nh). A total of 245 bats of 15 species were captured throughout the survey period, with two individuals of species complexes from the *Myotis* genus. Trapping productivity between surveys is displayed in figure 3 in relation to cumulative total number of species captured. Table 1 shows the species richness of the surveys conducted in each village in relation to the number of captures, the relative abundance of these species, as recorded in each, village is displayed in figure 4.

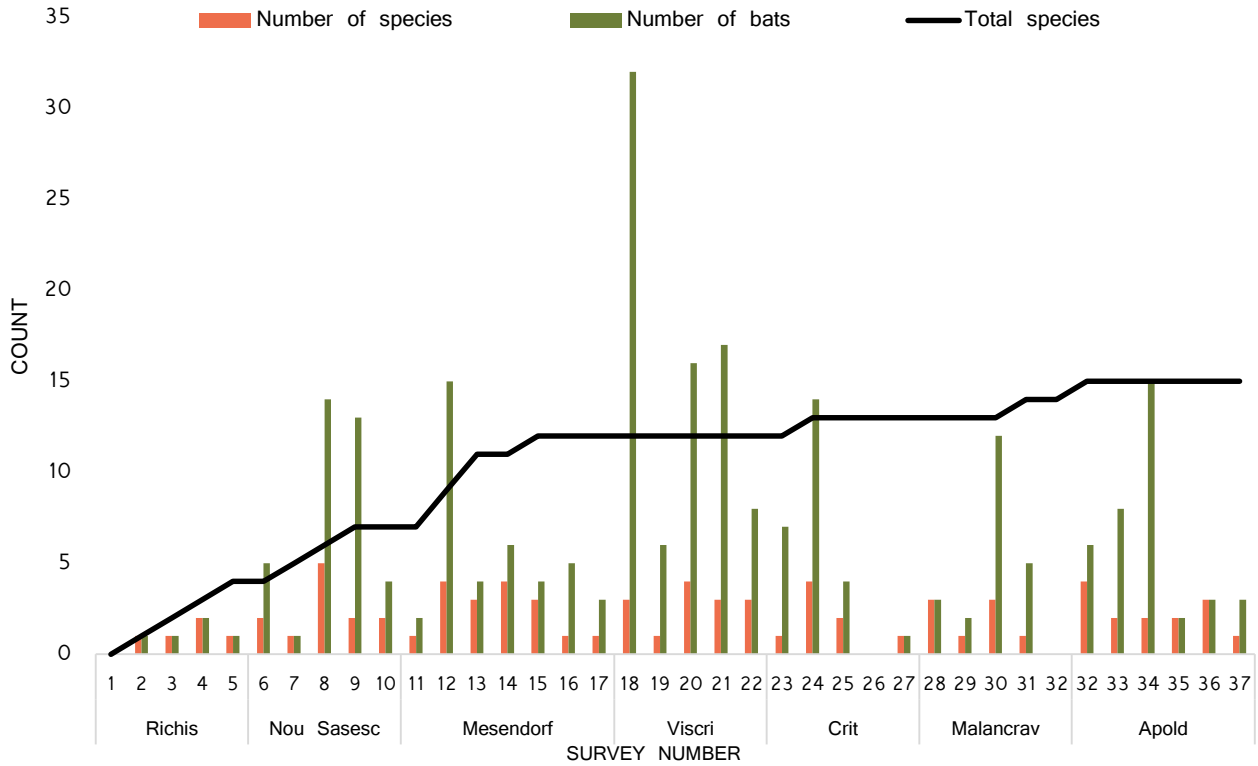

Figure 3. Trapping survey summary and species accumulation through 2018 expedition.

The capture summary displayed in figure 3 shows a steady increase in cumulative species identified throughout the trapping period, with no clear asymptote indicating a complete picture of all present species in the region. It is important to note that there are many factors affecting capture rates and species presence other than habitat differences between villages. Table 1 shows the total capture numbers from each village, the species are displayed by their relative contributions to the total number of captures in figure 4.

Table 1. Total bat captures and species richness from each village catchment.

Village	Captures	Species
Richis	5	4
Nou Sasesc	36	7
Mesendorf	38	8
Viscri	79	6
Crit	26	5
Malancrav	22	6
Apold	37	9

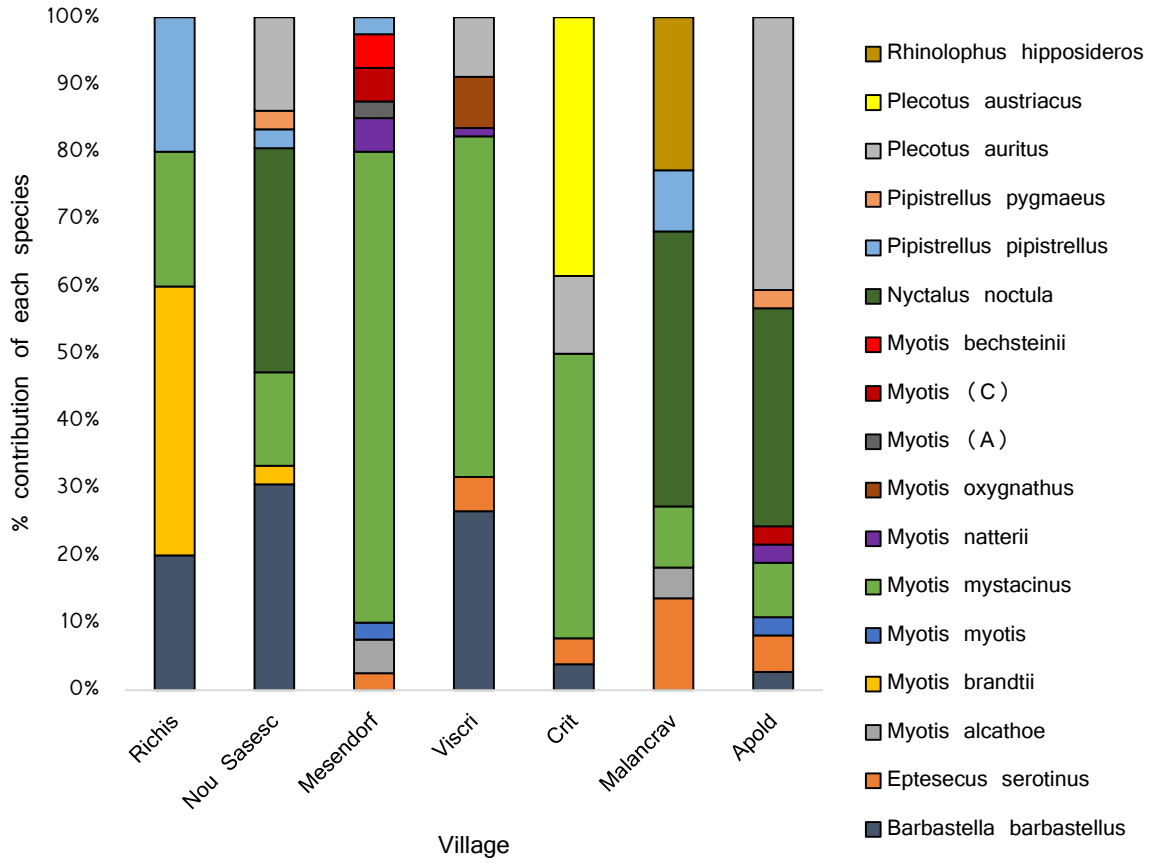

Figure 4. Percentage contribution of species recorded at village catchment areas through trapping, includes all individuals and species complexes.

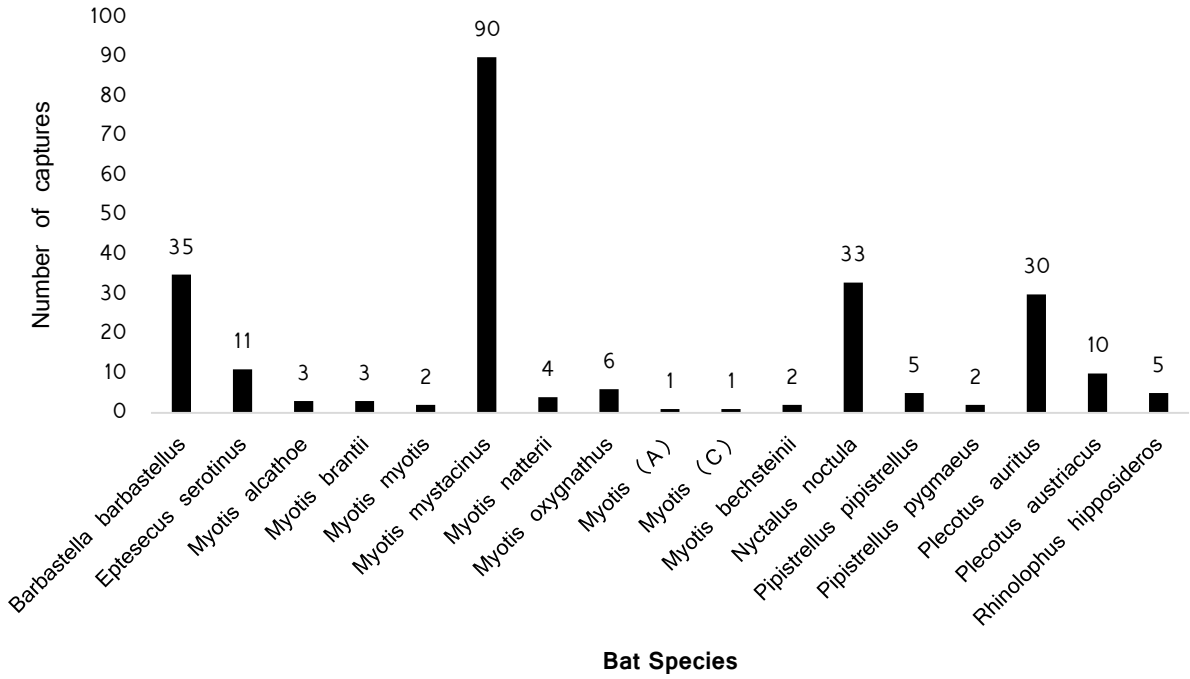

Figure 5. Totals of each species captured throughout 2018 survey period.

The species most commonly captured were *Myotis mystacinous* (37%), *Barbastella barbastellus* (14.3%), *Nyctalus noctula* (13.5%) and *Plecotus auritus* (12.6%). Figures 4 demonstrates that the most abundant species *Myotis mystacinus* was recorded at surveys in all 7 village catchments. Excluding the species complexes, four species were only surveyed in one of the 7 villages: *Rhinolophus hipposideros*, *Myotis Bechsteinii*, *Plecotus austriacus* and *Myotis oxygnathus.* Many of these species are represented in acoustic recordings, however some additional species were also identified, and some species were only identified through trapping. This highlights the need for the use of mixed methods to develop a complete picture of the species assemblage. An evaluation of species present is discussed in section 4. In total, 22 species were identified through both trapping and acoustic methods.

Acoustic data were not collected consistently and sampling effort was not controlled, these data are therefore not comparable between village catchments or habitats. Additionally, due to natural variation in amplitude and call characteristics between species, which affect detectability, these data are not directly comparable with the trapping data and additionally the number of passes does not represent relative abundance. Acoustic information is therefore only used as an indicator of additional species presence that may not have been recorded through trapping, and is not an indicator of abundance.

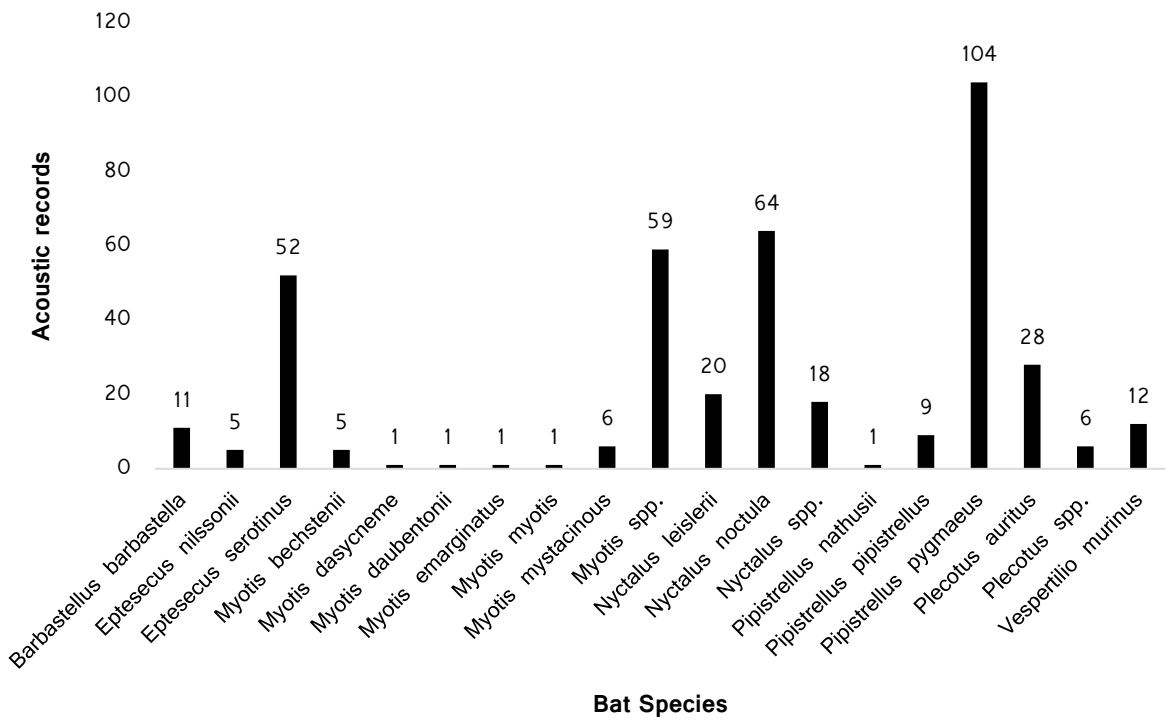

Figure 6. Number of bat passes recorded for each species

The array of species detected through acoustic recordings is markedly different to those recorded through trapping. Several species are recorded here that were not identified through trapping, namely: *Vespertilio murinus*, *Pipistrellus nathusii*, *Nyctalus leislerii*, *Myotis emarginatus*, *Myotis daubentonii*, *Myotis dasycneme* and *Eptesicus nilssonii*. However, several trapped species were not recorded acoustically: *Rhinolophus hipposideros*, *Plecotus austriacus*, *Myotis oxygnathus*, *Myotis nattererii*, *Myotis brandtii* and *Myotis alcathoe.*

A complete summary of methods used to record the presence of each species is available in table 3, Appendix B.

3.2. Richis

The village catchment area surrounding Richis was surveyed between June 22nd and June 26th 2018. Three sites were surveyed within the catchment area and five surveys were conducted in total. The only accessible survey site with water was in the centre of the village, both low disturbance sites were not near any water sources. Details of Richis trapping sites is available in Appendix C.

3.2.1 Species records

Trapping surveys yielded very low capture rates in Richis, with only 5 individual bats being captured across the five surveys, from 4 species of 4 genera. However, an additional 6 species were recorded through the handheld acoustic detector, and a large roost of another additional species was surveyed, indicating that this low capture rate may not be representative of the true bat assemblage of the area. In total 12 species were recorded from seven genera.

Of the trapped species, Richis was one of only two villages to yield the presence of *Myoits brandtii*, where two individuals were captured at different locations. Although the trapping success was relatively low, acoustic records indicated a high proportion of *Eptesicus serotinus* and *Nyctalus noctula*, in addition to high levels of Myotis spp. The presence of *Barbastella barbastellus* through both trapping and acoustic surveys indicates that there is sufficient old woodland to support specialised woodland species that require conservation attention. Richis was the only site where a recording was made of *Pipistrellus nathusii*.

3.2.2. Roosts

A known maternity roost of *Myotis myotis* was located in the Saxon fortified church of Richis. On inspection this year, it is clear there is still a sizeable maternity colony present in this church. It was not possible to quantify this colony, as most individuals were not visible as they roost behind slats on the inside of the roof, and it was not possible to get an accurate count through an emergence survey due to the height of the roost in the steeple of the church.

Evidence noted was a large quantity of guano build up in the tower, and numerous dead bats. Adult and juveniles bats were seen inside of the tower and identified as *Myotis myotis*. It is not possible to rule out the presence of other species, such as *Myotis oxygnathus*, as these are visually similar and known to roost in mixed colonies. There are multiple small holes in the steeple itself and several open windows for emergence/re-emergence.

Figure 7. Photographs depicting the *Myotis myotis* roost in Richis fortified Saxon church.

Pictured above: Build-up of droppings on top floor of clock tower (top left), adult *M.myotis* on outside of interior slats (top right), adult and juvenile M.myotis on a wooden beam at the top of the interior of the clock tower (bottom left), Richis clock tower from outside (bottom right).

3.3. Nou Sasesc

The village catchment area surrounding Nou Sasesc was surveyed between June 28th and July 2nd 2018. Four sites were surveyed in the area and five surveys were conducted in total. NS01PO (pond site) was surveyed twice due to high wind and rainy conditions on the first night, leading to low captures. The two woodland edge sites were in close proximity to each other, this was because this area was a large patch of woodland that was easily accessible from basecamp and the habitat varied along the edge from low to high canopy with less scrub-level vegetation, meaning that, despite being close together, they had different characteristics for foraging bats. Details of Nou Sasesc trapping sites are available in Appendix C.

3.3.1 Species records

Trapping surveys yielded 36 captured bats in Nou Sasesc, comprising of 7 species from 4 genera. An additional 3 species from 2 genera were identified from acoustic records, and one individual *Plecotus auritus* was seen roosting in one of the fortified church buildings. In total 10 species were recorded from 6 genera in this catchment area.

The trapping data from Nou Sasesc consisted of a very high proportion of *Nyctalus noctula* (33.3%) and *Barbastella barbastellus* (30.5%). At the pond site, only *N.noctula* and *P.pygmaeus* were captured, with all the records for *N.noctula* being from this location. Similarly, all records of *B.barbastellus* came from the two woodland sites, showing distinct species assemblages between the two habitats.

3.3.2 Roosts

Only one roost was classified in Nou Sasesc; a single *P.auritus*, found roosting in the bell tower in the external clock building to the main church. No evidence was found of a *Myotis myotis* roost as has been previously recorded at this site.

3.4. Mesendorf

The village catchment area surrounding Mesendorf was surveyed between 4th of July and the 10th of July 2018. Six sites were surveyed in the area and seven surveys were conducted in total. MES02WA was surveyed twice as the first survey recorded captured individuals of *Myotis alcathoe*, a data deficient species of which the range in Romania is unknown. The second trapping survey was conducted in order to collect more samples from this rare species, although no more individuals were captured. The two woodland edge sites are located in close proximity to the church, this was due to a highly variable habitat in this area, where a large un-managed orchard behind the church leads up into a large patch of old growth beech/oak woodland. The aim was to trap intensively in the variable habitat in this area as it was relatively accessible to us. Details of Mesendorf trapping sites are available in Appendix C.

3.4.1 Species records

Trapping surveys yielded 38 captured bats in Mesendorf, comprising of 7 species from 3 genera and one un-identifiable bat which was noted as *Myotis alcathoe/mystacinus*, however, both of these species are recorded at this site. Acoustic recordings identified no additional species, and only identified bats from the *Myotis* genus.

Mesendorf was notably rich in *Myotis* species, which comprised 92% of all the captures, 73.7% of the total captures were *Myotis mystacinus*. This was also the only site during the expedition in which *Myotis bechsteinii* and *Myotis alcathoe* were captured. These are important records as *M.bechsteinii* is a threatened species with high fidelity to old-growth woodland and Myotis alcathoe is a data deficient species with an unknown distribution. Other woodland-associated species include *Myotis nattererii* which was only recorded here and one other village.

3.4.2 Roosts

The Saxon fortified church in Mesendorf is likely to house a number of bats. On inspection, droppings were found in the main clock tower as well as the main roof void above the church hall and one outbuilding in the courtyard. The droppings found in the roof void were few and very old, these were small, likely to be *Pipistrellus* of small *Myotis*. After placing an acoustic recorder inside the roof void, no bat calls were recorded at all on the night the church was surveyed, this may be affected by the presence of two tawny owls which also inhabit this roof void. Small droppings were also found in the main outbuilding in the courtyard, although

no bats were seen roosting here, *Myotis mystacinus* were trapped in close proximity, so it is feasible they are using this building to some degree.

In the main clock tower of the church, a single *Myotis myotis* was seen roosting in a wall crevice on the third floor. There was no large build of droppings or any other evidence of their presence, so it is unlikely this is a maternity colony; although this cannot be ruled out with the evidence presented here. Large droppings that were feasibly produced by large Myotis such as these were very few on the rafters in the tower.

There were some small quantities of smaller droppings present on each floor, of an unknown species. One individual *Plecotus auritus* was captured in the bell tower, indicating that this species also utilises the building. This building is open to tourists and regularly cleaned, therefore it is not reliable to estimate levels of bat occupancy from these droppings.

Figure 8. Roost at the Saxon church tower in Mesendorf

Pictured above: A single *M.myotis* seen roosting inside the tower during daylight (top left), small droppings built up on rafters in the tower (top right). Fortified church and outbuildings from outside (bottom).

3.5. Viscri

The village catchment area surrounding Viscri was surveyed between the 12th and 16th of July 2018. Four sites were surveyed in the area and five surveys were conducted in total. VI01WE was surveyed twice due to a very high capture rate on the first survey, indicating a large population of bats in this area, this site was repeated to see if any more woodland species were present. Access to a project vehicle was granted at Viscri, therefore the trapping sites cover a wider range within the village catchment area. Viscri had the highest capture success of any village catchment by a large margin, and also the highest number of species. Details of Viscri trapping sites are available in Appendix C.

3.5.1 Species records

Trapping surveys in Viscri yielded a total of 79 captures of 6 species from 4 genera. One additional species, *Myotis myotis*, was identified through being seen at a roost. An additional 6 species were identified through acoustic recordings, including the only recording of *Myotis dasycneme* throughout the expedition. In total 13 species were identified, from 7 genera, as being present in Viscri.

Of the number of captures found here, a high proportion of these were *Myotis mystacinus* (50.6%), which were recorded at all the sites in this village. There was also a high proportion of *Barbastellus barbastella* (26.6%), although these were found only at the woodland sites. Other woodland specialists were recorded such as *Myotis nattererii*, through trapping, and *Myotis bechsteinii*, through acoustics. Viscri is the only village catchment where evidence of *Myotis oxygnathus* was discovered, several of these were trapped at the church site which was then determined to be a roosting colony of this species.

3.5.2 Roosts

Visual inspection of the interior of the fortified Saxon church at Viscri showed immediate evidence of large numbers of bats. Droppings of various sizes were seen on all floors of the clock tower, including in the roof void above the church hall. As the church is open to the public, the floors are cleaned regularly and droppings cannot be used as a reliable indicator of colony size. Although, oil staining was seen around several deep crevices in the centuries old stone walls on the ground and middle floors, indicating the presence of bats for many years. *Myotis myotis* were seen in these crevices on the ground and first floor of the clock tower, with a large aggregation in the crevices of the stone ceiling of the ground floor. A single *Plecotus auritus* was seen on a wooden rafter in the roof

void with a juvenile suckling, indicating that this is a maternity roost for this species. Additionally, one *Eptesicus serotinus* was seen on a rafter in the roof void and several whiskered bats (*Myotis alcathoe/brandts/mystacinus*) were seen emerging from crevices in the top of the bell tower at dusk.

Through trapping in the courtyard of the church, a number of *M.oxygnathus* were seen to be utilising the area in the immediate vicinity to the church and six males were captured. This means that it is extremely likely that this species are also roosting in this compound, as they are known to share roosting space with *M.myotis*.

All in all, this means that the fortified Saxon church in Viscri is used as roosting habitat for at least five species; a known maternity roost for *P.auritus*, and very likely to be a maternity colony for *M.myotis* and *M.oxygnathus.*

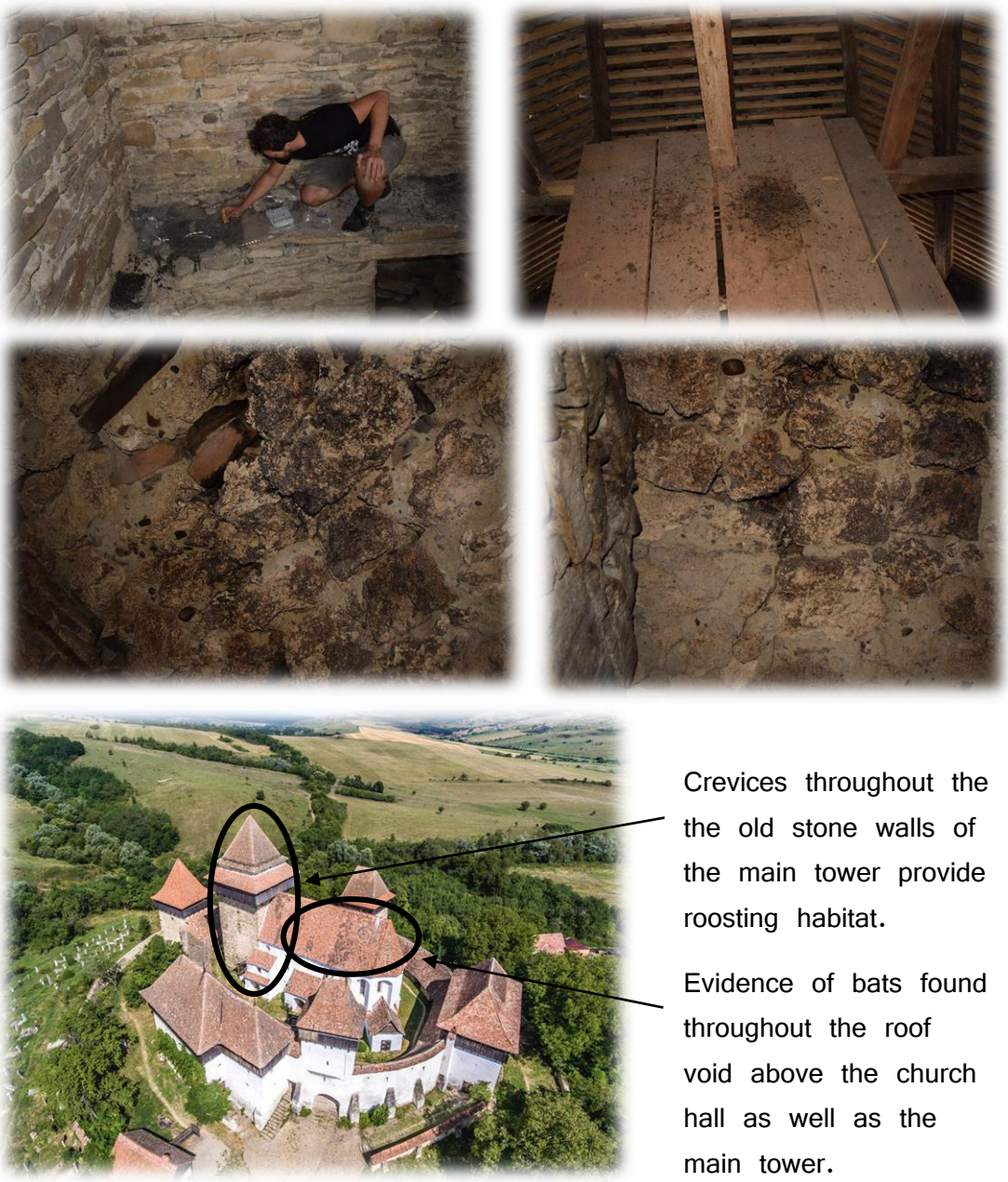

Figure 9. Viscri Saxon church roof

Pictured: Large aggregations of droppings on difficult to reach wall ledges (top left), droppings at the far end of the roof void above the hall (top right), oil staining around crevices used by roosting bats on the first floor (middle left), and ground floor (middle right), aerial view of Viscri church (bottom).

3.6. Crit

The village catchment area surround Crit was surveyed between the 18th and 23rd of July 2018. Five surveys were carried out over five different trapping sites. The weather was particularly poor during the surveys at Crit and there was some precipitation most nights and often heavy wind; limiting the survey time and the distance that could be travelled. This is likely to have impacted the capture success and detection of bats in this area, relative to other villages. Details of trapping sites in Crit are available in Appendix C.

3.6.1 Species records

Trapping surveys in Crit gave a total of 26 bats, made up of 5 species from 4 genera. An additional 4 species were identified through acoustic recordings, resulting in a total of 9 species from 7 genera.

As with other villages, *Myotis mystacinus* was an abundant species in Crit and represented by a high proportion in the capture data (42.3%). The presence of *Barbastella barbastellus* at the woodland site is a positive indicator of woodland habitat quality. Crit was also the only village catchment where the presence of *Plecotus austriacus* was confirmed. *P.austriacus* was caught in high numbers in the grounds of the Saxon fortified church of Crit; the presence of a high number of juvenile bats (n=9) of both sexes indicates that there is a maternity roost of this species somewhere in the compound.

3.6.2 Roosts

The interior of the Saxon church at Crit was inspected for signs of bat presence, although access was not granted to many of the outbuildings which were also likely to have suitable roost features. Patches of dry droppings were found in the roof void above the church hall and scattered throughout the tower, and one unidentifiable bat torso was found. Although, no direct signs of recent bat activity were seen. Through surveying the courtyard for bats during the night, a high abundance of *Plectous* species were recorded and trapped, notably many juvenile *P.austriacus* and one lactating female. There was also visibly a lot of *Plecotus* activity in the courtyard; bats socialising and foraging. This indicates that there is almost certainly a maternity colony somewhere in the grounds of the church, and potentially roosts of other species in the outbuildings.

3.7. Malancrav

The village catchment area surrounding Malancrav was surveyed between the 25th and 29th of July 2018. Five surveys were carried out over five different trapping sites. One survey yielded no captures (MA02WE), this is likely due to bad weather conditions on this evening and therefore woodland sites are under-represented for this village catchment. Another of the surveys was specifically aimed at emergence trapping to collect *Rhinolophus hipposideros* bats at a known roost, the abundance of this species is therefore not relative to others as this was a targeted effort to monitor this inaccessible roost. Details of trapping sites in Malancrav are available in Appendix C.

3.7.1 Species records

Trapping surveys in Malancrav yielded a total of 22 bats; 6 species of 5 genera. An additional species was identified through acoustic recordings, resulting in a total of 7 species from 5 genera.

Malancrav was the only village area to provide records for *R.hipposideros*, thanks to a targeted trapping effort at a known roost. The most common species here was Nyctalus noctula which was caught in abundance on one survey at a water body. A single capture of *Myotis alcathoe*, was also recorded in woodland.

3.7.2 Roosts

The Saxon church in Malancrav was inspected internally for signs of bats, but no evidence was found. It is important to note that this church appears to be cleaned more regularly than those in other villages. Access was not granted to survey at this property at night, so it cannot be determined whether this building is still being used by bats.

A roost of *R.hipposideros,* known about from previous expeditions, resides the the cellar of a small school in the village centre. The basement to this cellar is inaccessible so a harp trap was placed at an emergence point to determine the sex and breeding status of the roosting individuals. Five bats were trapped, including a lactating female and several sub-adult bats. This indicates that this is a maternity colony of these bats. It was observed that several bats were still flying in the roost after the survey had ended, it is therefore un-reliable to assume the size of this roosting colony.

3.8. Apold

The village catchment surrounding Apold was surveyed between the 1st and 6th of August 2018. Six surveys were carried out over five sites with AP02WA being surveyed twice. This site was repeated due to being a body of water surrounded by a mosaic of habitats, including high nature value grassland and old-growth woodland, which yielded high capture rates on the first repetition. Although no new species were captured on the repeated attempt. Details of trapping sites in Apold are available in Appendix C.

3.8.1 Species records

A total of 37 bats were captured at Apold, comprising of 9 species from 6 genera. A further 4 species were identified from acoustics, bringing the total to 13 species from 7 genera.

Apold was the only village catchment to provide evidence of *Myotis emarginatus* and *Myotis daubentonii*; both of which were recorded on acoustic data by water bodies. The most common species captured was *Plecotus auritus* (41%), this species was captured in woodland and urban sites. A single *Myotis myotis*, was captured at a pond site; the only capture of this species whilst foraging.

3.8.2 Roosts

The fortified Saxon church at Apold was inspected internally and evidence of use by bats was found throughout bell tower building. Small amounts of bat droppings were found throughout the building and *P.auritus* and whiskered bats were seen roosting in crevices between rafters on the top floor of the tower. The courtyard of the church was surveyed in the evening and several *P.auritus* were seen emerging via the doorway which is usually sealed by a barred gate, the bats seem to have no trouble flying through this gate. Lactating females and juveniles were captured during the survey, indicating this is a maternity colony occupying the building. *Eptesicus serotinus* were also captured during the survey, but it is unclear whether these bats are utilising the building itself.

4. Evaluation

22 species of bats were identified using all methods throughout the survey period, when considering all villages and habitat types. Of these species, 15 were identified to a high level of certainty through identification in the hand. Although, faecal samples from *M.alcathoe* should be used for confirmation of this species as it is poorly understood and difficult to identify. Of the seven additional species identified through acoustic records, several of these should be treated with caution as very low numbers of recordings were taken (in some cases only one pass) which leaves a large margin for type 1 error (see figure 5). Although, all of the species recorded here are within their known range, a more targeted effort should be used in future to confirm their presence with more certainty. These species are evaluated later on in this section.

The diverse bat fauna identified in this study indicates that this region is important habitat for a number of species, and provides a good indication of ecosystem health and availability of roosting and foraging habitat for many species. Continuous monitoring of the bat populations in this area will infer any changes in the landscape.

All species identified in previous expeditions were recorded in this study, including several new species. Abundance data from the trapping conducted in these surveys is not comparable to acoustic data recorded in previous years, so it is important that the continued programme focusses on trapping as a means to infer species abundance.

4.1. Roost inspections

Roost visits focussed primarily on the Saxon churches present in the centre of each village catchment. Excluding Malancrav, where we were not granted night access, all these ancient buildings showed signs of bat presence of various levels. The Saxon churches are important sites with diverse roost features that enable, in some cases, multiple species to colonise them. The roosts surveyed are evaluated below.

4.1.1. Richis Saxon church bell tower

A sizeable *M.myotis* maternity colony is still present here. Abundance estimates were not possible but from faecal evidence this is likely a large colony of several hundred bats. This roost should continue to be monitored and the Romanian centre for bat research and conservation will be notified. This is the largest bat roost

identified throughout the expedition. The presence of juvenile bats shows that this is a high conservation priority roost for this species.

4.1.2. Bell tower outbuilding of Nou Sasesc church

Only one *P.auritus* was seen roosting here, however it is likely more are present due to the numerous roost features and presence of droppings. Access was not granted to the main church building this year, which has been previously speculated to be an *M.myotis* roost, due to the presence of droppings. No bats were captured directly in the area of the church so it is unknown if bats are rearing young here.

4.1.3. Mesendorf Saxon church bell tower and outbuilding

Droppings of various sizes were found here, indicating the presence of multiple species; *P.auritus*, *M.mystacinus* and *M.myotis* were confirmed here. This roost has previously been identified as roosting habitat only for *M.mystacinus*, so this evidence highlights the important roosting habitat for multiple species here. Lactating and juvenile *M.mystacinus* were captured here showing that this is likely a maternity colony for this species. It is unknown to what end other bats are using this roost.

4.1.4. Viscri Saxon church

This church is roosting habitat for several species, including large numbers of mouse-eared bats. These buildings have previously been identified as roosting habitat for *M.myotis*, *E.serotinus* and *M.mystacinus.* The discovery of *M.oxygnathus* at this roost is new evidence for an additional species, although only male bats were identified. The confirmed presence of lactating and juvenile *P.auritus* shows that this is a maternity roost of this species. This building is therefore an important site which provides roosting space for a mixed-species colony. Further evidence should be collected to see if any other bats are breeding here.

4.1.5. Crit Saxon church

Dropping evidence was found inside the tower of Crit's church, but no clear evidence of recent bat activity was found. The capture of juvenile and lactating adult *P.austriacus* indicates that these bats are roosting somewhere in the vicinity and efforts should be made to locate this roost so that it can be conserved. Previous surveys have identified the presence of *M.myotis* bats but there was no evidence of this here.

4.1.6. Malancrav school cellar

Records from this roost are identical to what has been recorded in previous years. This cellar is a maternity roost for a small breeding colony of *R.hipposideros*, numbers seem to remain constant each year indicating roost fidelity is high and that the roost is at maximum occupancy.

4.1.7. Malancrav Saxon church

No evidence of bat droppings was found on internal inspection of this roost. Access was denied at night it is impossible to determine whether this roost is still being used by *P.austriacus* as has been recorded in previous years. The entire building is heavily used by tourists and cleaned regularly so a full emergence survey is necessary here to determine whether this is still an active roost.

4.1.8. Apold Saxon church

This has been previously recorded as a roost for *P.austriacus* in 2014, however surveys in 2018 provided no evidence for the presence of this species. *P.auritus* bats were seen emerging from the clock tower building and several juveniles and lactating females were caught, providing new evidence for a maternity colony inside of the tower. No evidence of *M.myotis* bats was identified as in previous years.

4.2. Species

4.2.1 *Barbastella barbastellus*

Barbastelle bats were identified at villages in Richis, Nou Sasesc, Viscri, Crit and Apold. Lactating female, juvenile and breeding male bats were caught commonly.

These bats are known to be generally rare and occur at low densities, they are also closely linked to old-growth forest and particularly Oak trees. This indicates that the forested areas of Nou Sasesc and Viscri are particularly important habitat for this species as they occur there in abundance. Barbastelle bats are known to have high fidelity to forest patches for roosting and foraging, not easily colonising new areas. They are also known to be particularly sensitive to pesticide use as their diet consists primarily of large moths.

Their presence within the Târnava Mare region indicates that there is good quality mature woodland and a healthy lepidoptera population. The species is likely benefitting from low-levels of agricultural pesticides and large areas of flower meadows which al. This species is classified as 'near threatened' under the international union for the conservation of nature (IUCN) classification, due its

declining habitat, and so this region is of conservation importance for this species. This species is also listed under annex II of the EU habitats directive and therefore requires special measures for conservation, including the designation of Special Areas for Conservation.

Figure 10. *Barbastella barbastellus* captured in woodland near Viscri.

4.2.2. *Eptesicus nilssonii*

This species was recorded via acoustic detection at Richis and Nou Sasesc. This species is known to be widespread and abundant, with an adaptable diet and roosting behaviour. It is classified as a species of least concern by the IUCN.

4.2.3. *Eptesicus serotinus*

This species was recorded in every village catchment throughout the survey period. It was recorded via acoustics in Richis and Nou Sasesc, and trapped in every other village. A roosting bat was discovered in Viscri. This is a widespread and abundant species classified as least concern by the IUCN. Its diet consists predominantly of large beetles and moths, hence its presence throughout the region is indicative of a diverse invertebrate population.

Figure 11. *Eptesecus serotinus* captured in urban habitat in Viscri.

4.2.4. *Myotis dasycneme*

One acoustic recording from Viscri resembles the call signature of this species. The location is within its range and fits with the species foraging requirements, by being near a water body. However, due to such a low detection rate, the presence of this species cannot be confirmed with any surety. IUCN classify this as near threatened; as it is a conservation priority species, more efforts should be made to determine the presence of the species, such as targeted trapping efforts.

4.2.5. *Myotis daubentonii*

One acoustic recording from Apold resembles the call signature of this species. Similarly to *M.dasycneme*, this species is associated with water bodies and the recording fits this description, having been recorded by a large lake. This species also has a large distribution and is of a low conservation priority.

4.2.6. *Myotis emarginatus*

One acoustic recording from Apold resembles the call signature of this species. This species has a large range but is unusual in that its diet is specialised on spiders and flies; it is therefore associated with cattle and agricultural land. It is currently classed as least concern. This species is listed under annex II of the EU habitats directive and therefore requires special measures for conservation, including the designation of Special Areas for Conservation. Several acoustic recordings of this species have been noted in the past from previous expeditions. Therefore, more investigation is required to assess if there is a significant population here.

4.2.7. *Myotis alcathoe*

Two specimens of this species were trapped in Mesendorf and one in Malancrav, consisting of one lactating adult female, one post-lactating adult female and one adult breeding male. These individuals were identified based on the following morphometric measurements: forearm 30.8 – 34.6mm (33mm, 33.5mm, and 31.2mm); fifth finger 37 – 44mm (38.5mm, 42.7mm and 38.1mm); thumb 3.8 – 5mm (5mm, 4.8mm and 4.8mm); foot <5.6mm (5.5mm, 5.6mm and 4.7mm), combined with a short tragus that does not reach the ear notch as with *M.mystacinus* and *M.brandtii.* All parties agreed that they were noticeably smaller than the *M.mystacinus* that occurred sympatrically.

These are important records as this is a data deficient species that is not suitably understood in terms of its range or conservation status. These are the first records of this species in this area and will go towards better understanding the distribution of this species.

Figure 12. *Myotis alcathoe* captured in Mesendorf over water.

4.2.8. *Myotis bechsteinii*

Two individuals were trapped in Mesendorf on two separate nights. Both were male, one juvenile and one adult. This is an easily recognisable species because of its very large ears. Acoustic recordings were also made of this species in Viscri

at an open water site. This is a rare sedentary species that is specialised to old-growth woodland and is subsequently in decline to due to loss and degradation of these habitats. It is classified as near threatened by the IUCN due its declining and fragmented population. It is also listed under annex II of the EU habitats directive and therefore requires special measures for conservation, including the designation of Special Areas for Conservation.

The presence of this species in the forested areas around Mesendorf and Viscri indicate a healthy woodland with a suitable proportion of old trees with hollows for roosting habitat. Its major threats are mismanagement of woodlands and pesticide use on farmland adjacent to woodland patches, so it is likely benefitting from the low-intensity agricultural practices in the area. More effort should be made to assess the population levels of this species in the wooded areas throughout the Târnava Mare region.

Figure 13. *Myotis bechsteinii* captured in woodland in Mesendorf.

4.2.9. *Myotis brandtii*

This species was captured on two occasions during the expedition: once in Richis, and once in Nou Sasesc. These individuals were separated from the other whiskered bat species by the presence of a protocone on the p4 tooth (absent in *M.mystacinus*), rounded tragus, heart shaped nostrils and standard morphometric measurements. This is a widespread and abundant bat, although few records exist from Romania. Typically associated with broadleaf and mixed woodland, in close proximity to water, although this species is known to hunt only non-aquatic insects. It is classified as a species of least concern by the IUCN.

Figure 14. *Myotis brandtii* captured in Richis over water.

4.2.10. *Myotis myotis*

This species was identified in Mesendorf, Richis, Viscri and Apold. One individual captured foraging over water in Apold, and roosts were identified in the other three villages. This species is known to feed on large ground-dwelling arthropods and therefore is a good indicator species for this aspect of the invertebrate community. Large roosting colonies are likely to have an impact on pest species as they are known to forage in agricultural areas, additionally feeding on dung beetles and invertebrate fauna attracted to livestock excrement. Their presence therefore is a clear consequence of low levels of pesticide usage and this continued practice is important for their conservation. They are known to be prevalent in mixed habitat and agricultural mosaic landscapes; an apt description of the current landscape in this regions. They are not currently at risk as their population is considered stable: IUCN classified least concern. They are however listed under annex II of the EU habitats directive and therefore requires special measures for conservation, including the designation of Special Areas for Conservation.

4.2.11. *Myotis mystacinus*

This species was by far the most abundant in capture records throughout the survey period, with 90 captures in total. This species is quite clearly prevalent throughout the region, and was found in all habitat types that were surveyed, including: buildings, woodland, water bodies and urban areas. Its near continuous presence and abundance, expecially in urban areas, is an indicator of the low levels of anthropogenic disturbance through light pollution, as this species does not appear to be affected. It is a widespread and abundant species and therefore classified as least concern by the IUCN.

4.2.12. *Myotis nattererii*

This species was captured in Mesendorf, Viscri and Apold; a total of four individuals were captured. This is a sedentary but widespread species, commonly associated with woodland but less specialised than other woodland species. Its distribution and abundance means that it is classed as least concern for the IUCN.

4.2.13. *Myotis oxygnathus*

Also known as *Myotis blythii*, this species was captured at its roost in Viscri which is the only location it is known to occur in the study region. Although, it is known to roost in mixed colonies with *M.myotis*, and may therefore be present but unrecorded in these other bat roosts.

This gregarious species forages in scrub and grassland habitats and is therefore a positive indicator of the biodiversity supported by local habitat. It likely benefits from the mosaic of pasture and flower meadows. Although its populations are decreasing in some countries, it is generally thought to be stable and therefore classified as least concern by the IUCN. However, its population trend in Romania is relatively unknown. This species is listed under annex II of the EU habitats directive and therefore requires special measures for conservation, including the designation of Special Areas for Conservation.

Figure 15. *Myotis oxygnathus* captured at Viscri by the fortified church.

4.2.14. *Nyctalus leisleri*

This species was identified from acoustic recordings at Nou Sasesc, Viscri, Crit, Malancrav and Apold. It is widely distributed and abundant, and therefore classified as least concern by the IUCN. This species is known to forage in a number of habitats including woodland, rivers and pasture.

4.2.15. *Nyctalus noctula*

This species occurred throughout the survey period on acoustic data, and was trapped in Nou Sasesc, Malancrav and Apold. This is a fast flying species that hunts at high altitudes; feeding on large moths and beetles. Consequently, it has only been caught over water where it is presumably coming down to lower altitudes to drink. Although, when caught it is always present in abundance, indicating that this is a very prevalent species in the region.

The presence of large numbers of these bats is a good indicator of a healthy invertebrate population, sustained by high nature value grasslands. This species is widely distributed and abundant, and is therefore classified as least concern by the IUCN. It is important to note that pregnant bats of this species were caught as late as 2nd of august, which very unusual at this stage of the season.

Figure 16. *Nyctalus noctula* captured over water near Apold.

4.2.16. *Pipistrellus nathusii*

One acoustic recording from Richis resembles the call signature of this species and therefore more effort should be made to determine its usage of this region with more certainty. This is a widespread, migratory species that is known to be adaptable to a range of habitats including woodland, edge habitats and wetland. It is not currently of any conservation concern, although its population trend is unknown. Currently classified at least concern by the IUCN.

4.2.17. *Pipistrellus pipistrellus*

This species was trapped in Richis, Nou Sasesc, Mesendorf and Malancrav. It was also identified in acoustic data from Richis and Malancrav. This species is very common throughout its large range, and is usually one of the most common bats in most of its range. It was mostly recorded in village centres throughout the survey period, which is typical of this species as it is known to be tolerant of light pollution; often seen actively foraging on street lamps. Due to its abundance it is currently listed as least concern by the IUCN.

4.2.18. *Pipistrellus pygmaeus*

This species was trapped in Nou Sasesc and Apold, in both cases by water bodies. Acoustic data also demonstrates this species' presence in Richis, Viscri and Crit. This is a common species that is closely associated with foraging over water bodies as it is known to preferentially feed on aquatic midges. It was only recently differentiated from *P.pipistrellus*, and therefore its full distribution is not fully understood. Generally it is thought to be less common than *P.pipistrellus* although the data presented here indicates that this is not the case in this region. Currently classified as least concern by the IUCN due to its abundance.

Figure 17. *Pipistrellus pygmaeus* captured by a lake near Apold

4.2.19. *Plecotus auritus*

This species was captured in Nou Sasesc, Viscri, Crit and Apold. It was also detected on acoustic data in Richis, and roosts were identified in Nou Sasesc and Apold. This species is generally associated with deciduous and coniferous woodland, gleaning moths and flies from foliage. It makes use of buildings and trees as roosts, so this species' presence in a mix of habitat types throughout the survey period indicates that it does well in this mixed landscape.

Figure 18. *Plecotus auritus* captured in the fortified church of Viscri

4.2.20. *Plecotus austriacus*

This species was only identified at Crit, where there is thought to be a breeding colony somewhere in the church compound. It has previously been identified roosting in Apold, although no evidence was found of this during the surveys in 2018. It is known to be a sedentary species that is associated with lowland valleys and open agricultural landscapes; preferring open and semi-open habitats. Recommended conservation practices include restoring hedgerows and scrubby areas; as it is known to be negatively impacted by intense agriculture. There is evidence of population decline in parts of this species' range, although it is still currently classed as least conern by the IUCN.

Figure 19. *Plecotus austriacus* captured outside the fortified church in Crit.

4.2.21. *Rhinolophus hipposideros*

This species was only captured at a roost in Malancrav. Rhinolophus species would be unlikely to be represented in the data without a targeted trapping effort, as these species forage for short bursts of time in a localised area and are generally under-represented in non-targeted trapping surveys.

This species is known to forage primarily along the edges of broadleaf deciduous woodland, avoiding open areas. It preys primarily on midges, moths and craneflies. The roost inside a building in the centre of Malancrav demonstrates the low levels of anthropogenic disturbance to its foraging habitat and the close proximity of woodland to the village centre. Winter and summer roosts are typically found 5-

10km of each other; so the hibernacula is likely nearby. This species is sensitive to habitat fragmentation and agricultural intensification. Despite this species being known to have a declining population trend, it is widespread and therefore classified as least concern by the IUCN. This species is listed under annex II of the EU habitats directive and therefore requires special measures for conservation, including the designation of Special Areas for Conservation.

Figure 20. *Rhinolophus hipposideros* outside its roost in Malancrav.

4.2.22. *Vespertilio murinus*

This species was recorded in acoustic data from Richis, Viscri, Crit and Apold. This migratory species has a very wide distribution and is known to adapt to a range of habitats including forest, agriculture, steppe and even arid habitat. This species tends to rely on rock crevices and buildings for its roosts, but occasionally uses trees. Its diet is primarily moths and beetles, so its presence in this region is a good indicator of a healthy invertebrate population. Due to its vast distribution and abundance it is classified as least concern under IUCN classifications.

4.3. Acoustic data

Acoustic records are not suitable for making comparisons between species presence and abundance between village catchments due to variances in recording effort. This creates recorder bias due to the likelihood of a species being detected in each village not being a direct result of its actual presence and abundance, but being affected by whether acoustic data was being collected at that time. Mesendorf and Malancrav in particular had very little acoustic data collected in comparison to the other village catchments, primarily due to logistical difficulties. The species richness of these village catchments may therefore be underestimated

in comparison to the other village catchments because less acoustic data was collected.

Nonetheless, the data that were collected provide a good indication of species presence that would not have been detected through trapping alone and therefore build a more complete picture of species richness in the wider area of Târnava Mare. Species with very low detection rate should not be considered to be present with 100% reliability due to the margin of error associated with acoustic analysis at low detection rates.

Recommendations for improving this aspect of the surveys are detailed in the following section.

5. Conclusions

The species identified in these surveys represent 69% of the species known to occur in Romania. The variety of bat species identified throughout this expedition highlight the high biodiversity value of the region. These bats feed on a range of different invertebrates and therefore provide a good indication that there is a substantial and diverse invertebrate population, which in turn demonstrates good quality provisional habitat.

This high bat species richness is likely to be a result of the array of ecological niches available because of the mosaic of different habitat types; including mature woodland which supports specialised woodland species. There are also species here that are known to benefit from low-intensity agriculture and the invertebrates associated with grassland and livestock manure; an indication that the diversity of bats here is higher than an entirely natural landscape. It is therefore sensible to conclude that the bat diversity in this region benefits from a structurally diverse landscape and low-intensity agricultural practices.

The presence of five bat species listed in annex II of the EU habitats directive demonstrates the need for continued management of this region in order to fulfil the EU's requirements under the Bern convention (1979) for the protection of species listed as being of importance to European biodiversity. It is therefore important to monitor the populations of these species in response to changes in this landscape, so that this can be taken into account when managing these areas with respect to cultural, economic and ecological protections. In order to achieve this, targeted trapping efforts should be conducted using acoustic lures and tagging to better understand the population dynamics of these rare and protected species.

The presence of small *Myotis* species throughout the village centres indicates that anthropogenic light is having little effect on the bat populations in these areas. In an urban area with higher levels of light pollution, *Myotis* species would be unlikely to inhabit these areas and *Pipistrellus* species would become more prevalent. Whilst *Pipistrellus* species were present in the village centres, they appear to be occurring sympatrically with *Myotis* which is a good sign that light pollution is not causing major disturbance.

Capture rates were higher at aquatic sites and structurally diverse roosting sites (the fortified Saxon churches in particular). This demonstrates the importance of these habitat features for bat foraging and roosting sites. The Saxon churches could provide important educational centres for public engagement with regards to awareness of the ecological importance of bats, and efforts should be made to protect the roost features of these buildings. This could also be beneficial for the churches themselves by generating public interest their ecological as well as historic value.

6. Recommendations

6.1. Survey methods

The focus of trapping during the survey period was effective in gaining useful information on the abundance of bat species between habitat types. Trapping surveys using mist nets and harp traps should be carried out at least five times per village, ideally in at least one site each from a woodland, urban and open water habitat. By continuing these methods in future surveys, and by repeating trapping sites, good data will be produced on population trends and dynamics within these populations of bats.

Surveying in this way also allowed for the collection of biological samples, which can be used for species identification and molecular research techniques. By collecting faecal and parasite samples that can be stored for extended periods of time, an archive of biological data is available which builds capacity for molecular studies on bat micro-biomes, population genetics and dietary analysis which can provide better insight into the ecology of bats in this landscape.

Through collecting habitat and weather data, these variables can be factored into studies that involve multivariate ecological modelling to infer their effect on capture rates, or to negate the effect when drawing conclusions about un-related drivers.

It is important that these methods be continued in future so these data are comparable over time.

The collection of morphometric measurements allows for external verification of species identification and for making intra-species comparisons between regions. The collection of consistent morphometric measurements will also be useful when identifying cryptic species in future expeditions. Although, collecting these should be at the survey leader's discretion due to time constraints and bat welfare.

Whilst focussing on trapping surveys, it is not possible to conduct walking bat transects with handheld detectors. It is recommended that the project purchase several static detectors so that remote sensing techniques can be implemented in a strategic fashion that still allows for extensive trapping. For example, static detectors could be placed in a stratified manner across habitat types in each village catchment, and then collected at the end. These could be aligned with the camera trapping surveys of large mammals for easier implementation. This would provide a more holistic picture of the bat assemblage in these village catchments by allowing for a much larger sampling area within each village. A limitation of trapping alone is the quantity of equipment which has to be transported, erected and dismantled, which causes logistical limitations on how much ground can be covered on foot.

6.2. Data sharing and research

Data should be shared openly with the Romanian Centre for Bat Research and Conservation (CBRC). This organisation collates this data for the better understanding of Romanian bat populations and all future efforts should openly collaborate. It is important to promote close links with Romanian wildlife research authorities and this has been neglected somewhat in the past. This will also benefit the project by discerning any existing knowledge of important bat roosts and species presence in this region. All data should be used to inform national as well as local policy makers on conservation issues regarding bats.

The data that has been collected thus far can be used to conduct research regarding landscape scale conservation issues to bats. The project has a good amount of spatial data for conducting habitat suitability analysis in this region and this could be conducted in the form of a research project. This will help to better understand how bats use this landscape and assess their potential population size.

The collection of biological samples allows for a range of molecular techniques to be implemented to better understand the ecology of the bats in this region, and this potential will only improve with the continued collection of samples year after year. Projects would vary in scale, and feasibility should be discussed with scientists with a relevant background. Nonetheless, potential projects that could be conducted include:

- Investigating ectoparasite communities between bat species and relating this to roosting and foraging behaviour.
- Conducting dietary analysis of faecal samples to investigate the nocturnal invertebrate population of the landscape. Either by genetics or by identifying fragments within faecal samples.
- Investigating the relatedness of sedentary bat species using population genetics, and inferring on features in the landscape. Either by looking at the bats themselves or the parasite communities.

6.3. Roosts

It was clear from investigating some buildings that restoration work had been conducted to various extents in several known bat roosts. It is important that the project informs local stakeholders of the importance of these bat roosts and works with the CBRC to ensure the protection of these bat colonies. Roosts should continue to be surveyed every year and where possible the colonies should be quantified. The project would benefit from access to an endoscope or thermal imaging camera to conduct these assessments.

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Appendix A. Variable descriptors

Table 2. Variable descriptors of trapping survey

Variable	Description
Survey Date	Survey date entered in YYMMDD format
Date entered	Date entered in datasheet YYMMDD format
Village	Village catchment area
Survey No	Chronological survey number
Site Code	Unique Site code with village initals and number of sites with habitat type e.g. NS02WE equates to Nou Sasesc second woodland-edge site (not the second repeat of Nou Sasesc Woodland-edge site 1) in other words; NS01WE and NS02WE are two unique woodland-edge trapping sites.
GPS North	GPS Northings in standard decimal format hddd.ddddd' with coordinate system WGS 1984
GPS East	GPS Eastings in standard decimal format hddd.ddddd' with coordinate system WGS 1984
Traps opened	Time traps opened in 24 hour format
Traps closed	time traps closed in 24 hour format
Habitat	Description of habitat type e.g. hedgrow, woodland edge, stream, pond or urban - try to include woodland characterising tree species if woodland
Trap locations	Description of Trap locations in survey
Clutter	Amount of eye-level vegetation clutter amongst trapping site, quantified on a rank scale of 0 to 4. (0 is open space, 1 is <25% and 4 is dense vegetation)
Canopy Cover %	Canopy cover % estimate, not applicable to urban or roost sites.
Canopy Height (m)	Canopy height in meters, measured using phone application where klinometer not available
Next to water	Is the trapping site nearby to open water source
Dist to Urban (m)	Distance to village centre, measured using distance tool in GIS from trapping site to 10m ring buffer around areas with street lights. Indicator of disturbance.
Area Mist net (m^2)	Area of mist nets surveyed, measured in square meters
No HTs	number of Harp traps used
Cloud cover	Rank order of cloud cover quantified as 0 to 4 (0 is no cloud, 1 is <25% 2 is <50% etc.)
Wind Speed (1-4)	Rank order of wind speed in 0 to 4 (0 is no wind, 4 is Gale force). Surveys not usually conducted when wind is greater than 2.
Temp start ©	Temperature at the start of the survey in degrees centigrade
Moonphase	Indicator of moon light intensity
Sunset	Official sunset time recorded in 24 hours
Sunrise	Official sunrise time recorded in 24 hours

Table 2. Data variables collected from each capture

Variable	Description
Handler Initials	Initials of handler taking morphometric measurements
Time captured	Time bat is discovered in trap in 24 hour format
Trap type	Harp trap or Mist net
FA (mm)	Forearm length in mm
FA side	Forearm side measured
Ear width (mm)	Width of outer ear at widest point
Ear Length (mm)	length of ear from base to tip
Tragus width (mm)	Width of tragus at widest point
Tragus length (mm)	length of tragus from base to tip
Tail Length (mm)	Length of tail from anus to tip
Thumb length (mm)	Length of the thumb from base of thumb pad to end of the thumb (excluding the nail)
Foot Length (mm)	length of foot prom the tip of the calcar to the end of the middle toe (excluding the nail)
Sex	Male. Female or Unknown
Age	Juvenile, Sub-Adult or Adult (Use 5th finger joints on wing and decipher by light shining through the joint) Breeding individuals can still be classed as sub-adults
Weight (g)	Weight of the bat in grams
Reproductive status	Reproducting status of the bat: Males can be Breeding (Br) or Non-Breeding (NB), Females can be Parous (P), Pregnant(Preg), Non-Parous(NP), Lactating(La) or Post-Lactating(PL)
Species	Species initials (when these overlap use first 4 letters of species name e.g. Myotis Myotis = Mmyot, Myostis Mystacinous = Mmyst)
Ring number	Bat number of each species per survey e.g. the 4th Barbastelle of a single survey would be BAT04BB
5th finger (mm)	Length of 5th finger, used to dinstinguish species
Parasites (Y/N)	Presence/absence of parasites
Call Sample	Call sample ID with Bat number, site code and date e.g. a call sample of the first whiskered bat caught on the 1st of July 2018 at the original woodland edge site in Nou Sasesc would be 180701_BAT01MMyst_NS01WE_Vocal
BioSample	Code for fecal/buccal sample e.g. A fecal sample taken on the 1st of July 2018 at the original woodland edge site in nou Sasesc from the second whiskered bat captured would be labelled as 180701_ BAT02MMyst_NS01WE_Fecal
Parasite sample	The sample code for parasites e.g. A flea taken from the first Barbastelle bat captured on the 1st of July 2018 at the original water body site in Richis would be labelled as 180701_BAT01BB_RI01WA_Flea
Photo ID	File location of ID photos with Unique code denoting date, site and Bat number.
Notes	Any other useful information, abnormalities etc.

Appendix B. Species records summary

Table 3. Summary of species records and methods （excluding species complex records）

	Village Catchment Area						
Species	**Richis**	**Nou Sasesc**	**Mesendorf**	**Viscri**	**Crit**	**Malancrav**	**Apold**
Barbastella barbastellus	A, T	A, T		A, T	T		T
Eptesicus nilssonii	A	A					
Eptesicus serotinus	A	A	T, R	A, T, R	T	T	T
Myotis dasycneme				A			
Myotis daubentonii							A
Myotis emarginatus							A
Myotis alcathoe			T			T	
Myotis bechsteinii			T	A			
Myotis brandtii	T	T					
Myotis myotis	R		T	R			A, T
Myotis mystacinus	A, T	T	A, T, R	A, T, R	T	T	A, T, R
Myotis nattererii			T	T			T
Myotis oxygnathus				T, R			
Nyctalus leislerii		A		A	A	A	A
Nyctalus noctula	A	A, T		A	A	A, T	A, T
Pipistrellus nathusii	A						
Pipistrellus pipistrellus	A, T	T	T			T	A
Pipistrellus pygmaeus	A	A, T		A	A		A, T
Plecotus auritus	A	A, T, R		A, T	A, T		A, T, R
Plecotus austriacus					T, R		
Rhinolophus hipposideros						T, R	
Vespertilio murinus	A			A	A		A

Appendix C. Trapping sites

Table 4. Summary of Richis trapping sites

Site	Surveys	Effort (m^2nh)	Characteristics/Notes
RI01WD	1	241	Old growth Beech/Oak woodland. High canopy, low clutter. Low disturbance.
RI01WE	2	309	Connecting ride and woodland edge between woodland patches. High clutter and low canopy. Low disturbance.
RI01WA	2	1097	Stream running through centre of Richis. No trees or scrub. High disturbance.
Total	5	1747	

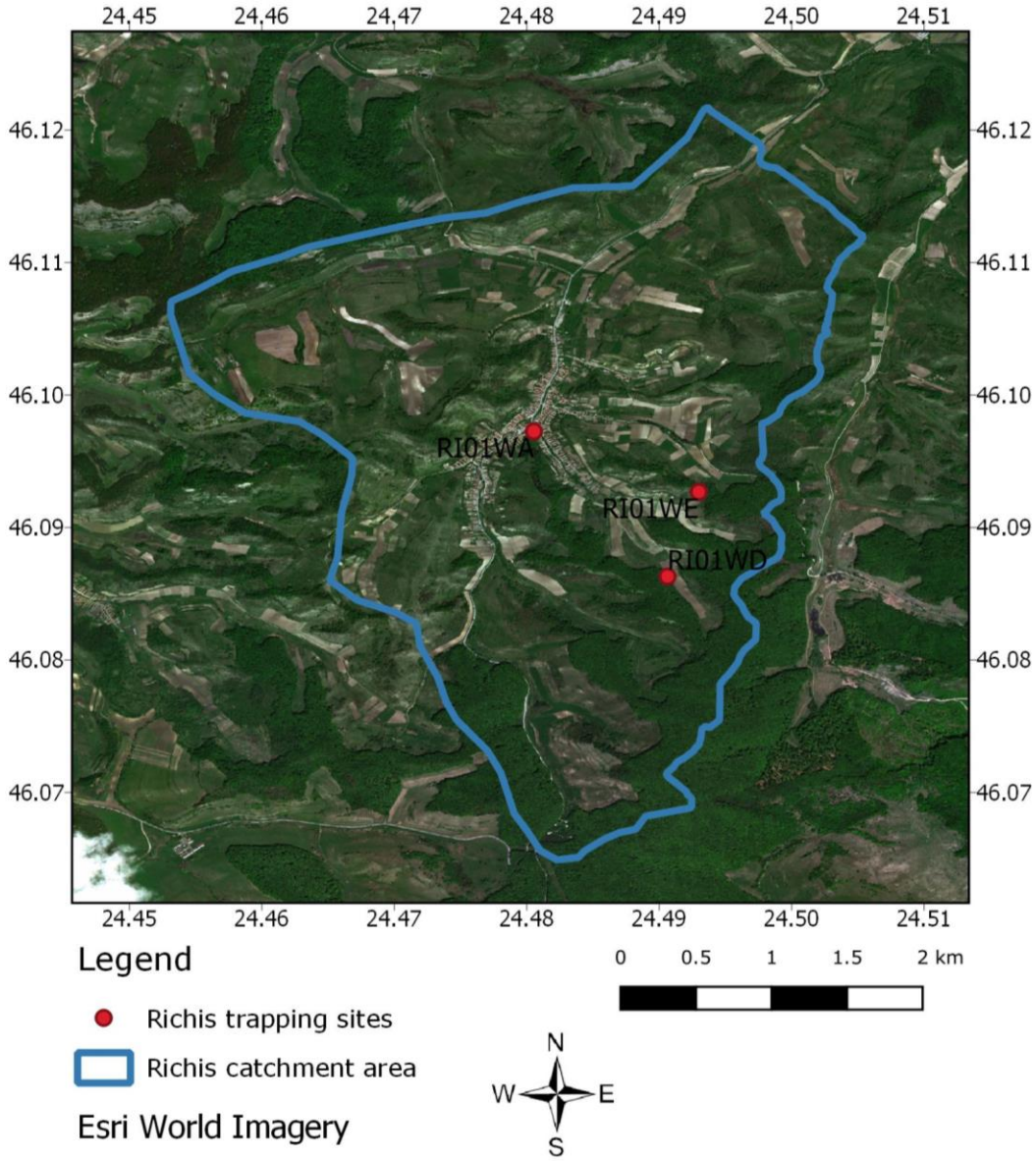

Figure 21. Richis catchment and trapping sites.

Table 5. Summary of Nou Sasesc trapping sites.

Site	Surveys	Effort (m^2nh)	Characteristics/Notes
NS01WE	1	747	Edge of mixed woodland including ride between patches. Moderate levels of cluttered vegetation.
NS02WE	1	756	Edge of mixed woodland to grazing pasture; low clutter, more open.
NS01PO	2	1186	Pond in village centre
NS01CH	1	405	Saxon fortified church in village centre and surrounding grounds
Total	5	3094	

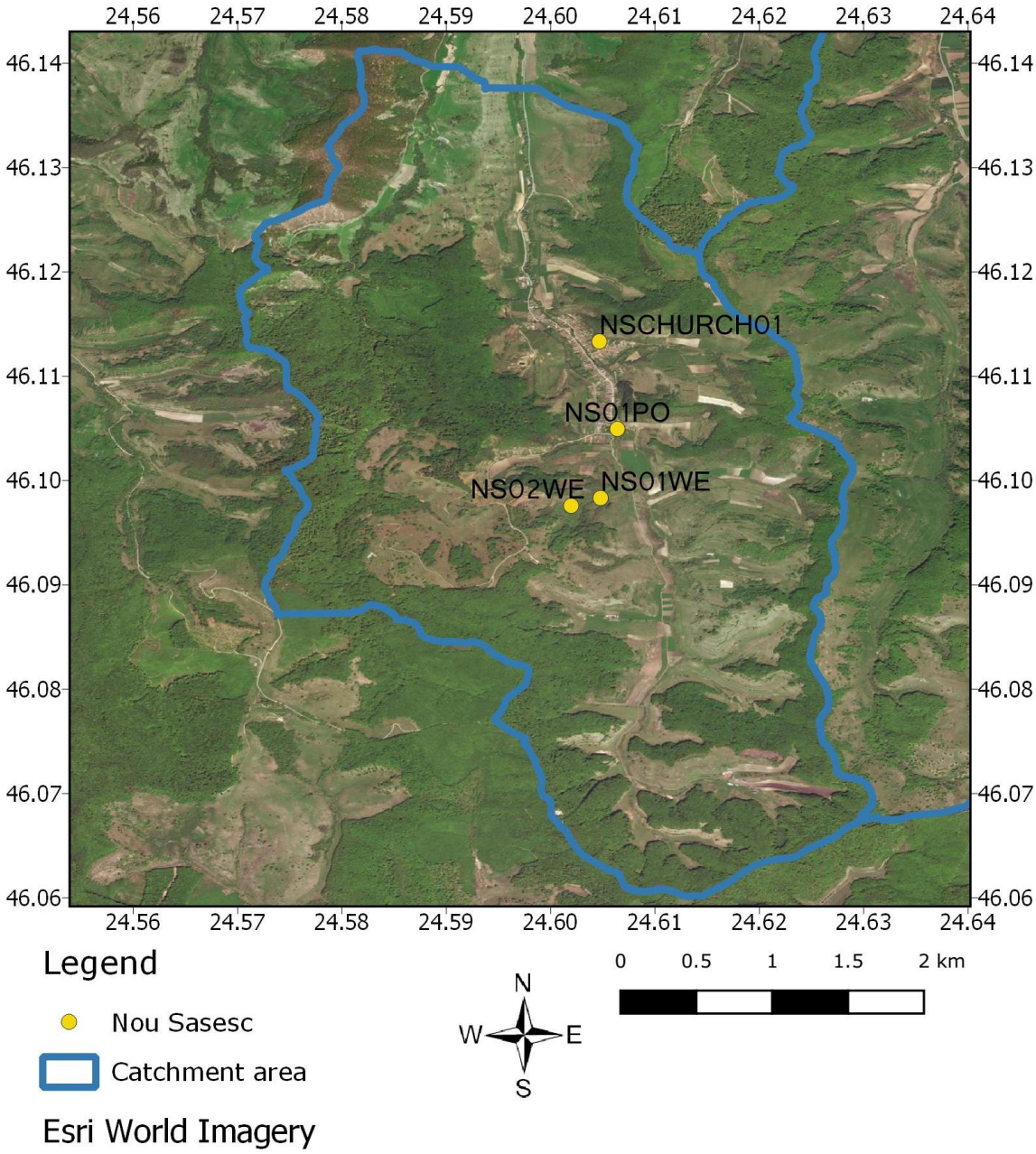

Figure 22. Nou Sasesc catchment area and trapping sites.

Table 6. Summary of Mesendorf trapping sites

Site	Surveys	Effort (m^2nh)	Characteristics/Notes
MES01WA	1	4900	Stream in village centre
MES02WA	2	12045.6	Stream in willow scrub between grassland
MES01WE	1	5890	Beech/Oak woodland edge
MES02WE	1	6363	Overgrown orchard by woodland
MES01CH	1	6573	Saxon church courtyard
MES03WA	1	6372	Stream through bridge by road, near woodland
Total	7	42505	

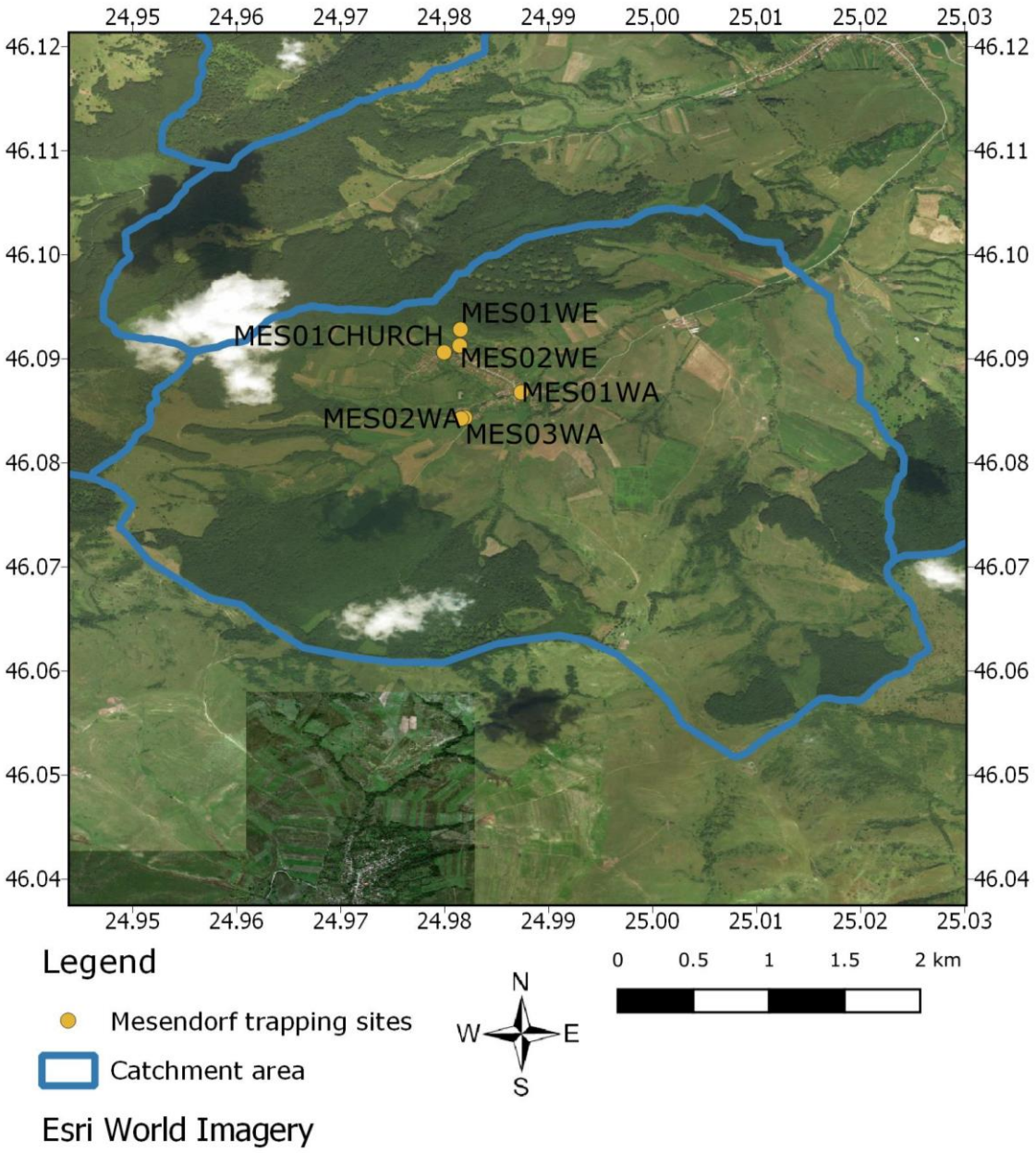

Figure 23. Mesendorf catchment area and trapping sites

Table 7. Summary of Viscri trapping sites

Site	Surveys	Effort (m^2nh)	Characteristics/Notes
VI01WE	2	1182	Woodland edge of beech/oak woodland near clearing
VI01WA	1	270	Artificial ponds near agricultural land, hedgerow by stream
VI01CH	1	244	Viscri fortified Saxon church
VI01WD	1	480	Mixed woodland, old growth
Total	5	2176	

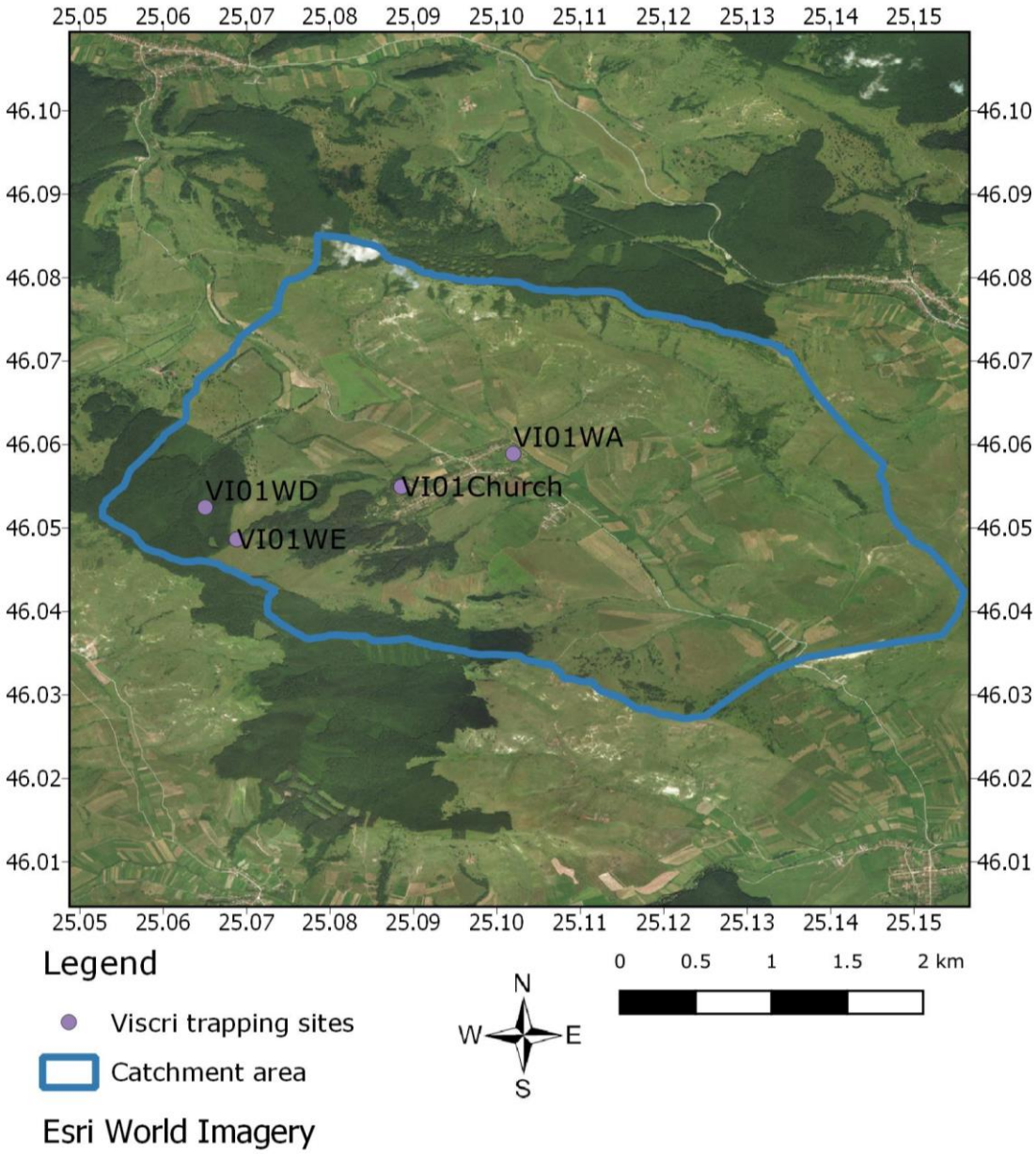

Figure 24. Viscri catchment area and trapping sites.

Table 8. Summary of Crit trapping sites

Site	Surveys	Effort (m^2nh)	Characteristics/Notes
CR01WA	1	150	Stream on edge of village, high density clutter
CR01CH	1	480	Crit fortified Saxon church
CR01WE	1	402	Edge of woodland patch on village outskirts, by grazing pasture with stream
CR02WE	1	411	Old growth woodland edge by high nature value grassland
CR01UR	1	281	Trapping between buildings in village
Total	5	1725	

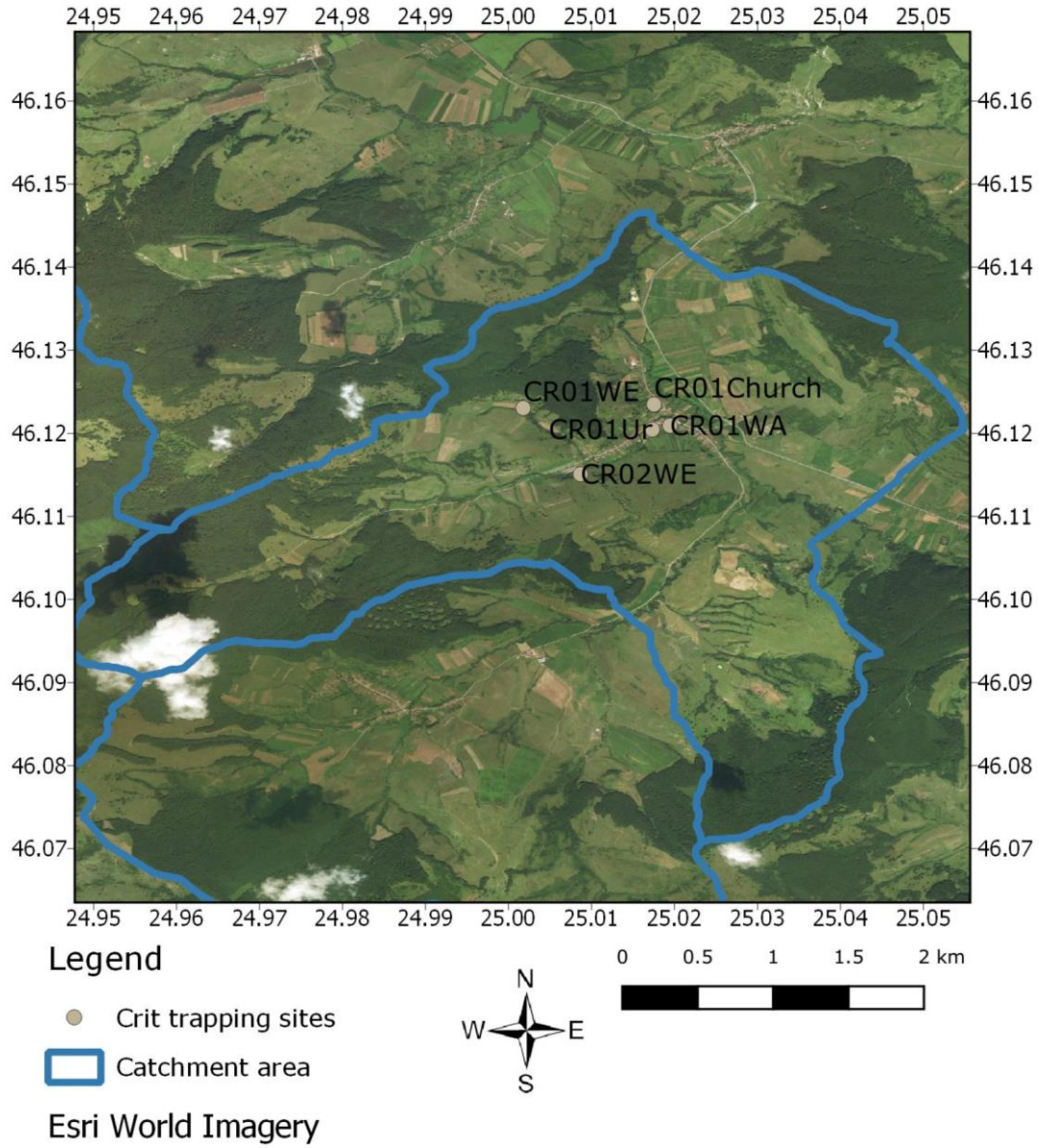

Figure 25. Crit catchment area and trapping sites.

Table 9. Summary of Malancrav trapping sites

Site	Surveys	Effort (m^2nh)	Characteristics/Notes
MA01WE	1	596	Woodland edge; Beech/Oak. Steep valley, low clutter
MA01WA	1	183	Stream through village
MA02WA	1	984	Fishing pond amongst mixed grassland types including agriculture, near forest
MA01Roost	1	146	*R.hipposideros* roost in village centre
MA02WE	1	253	Woodland edge; pine dominated
Total	5	2164	

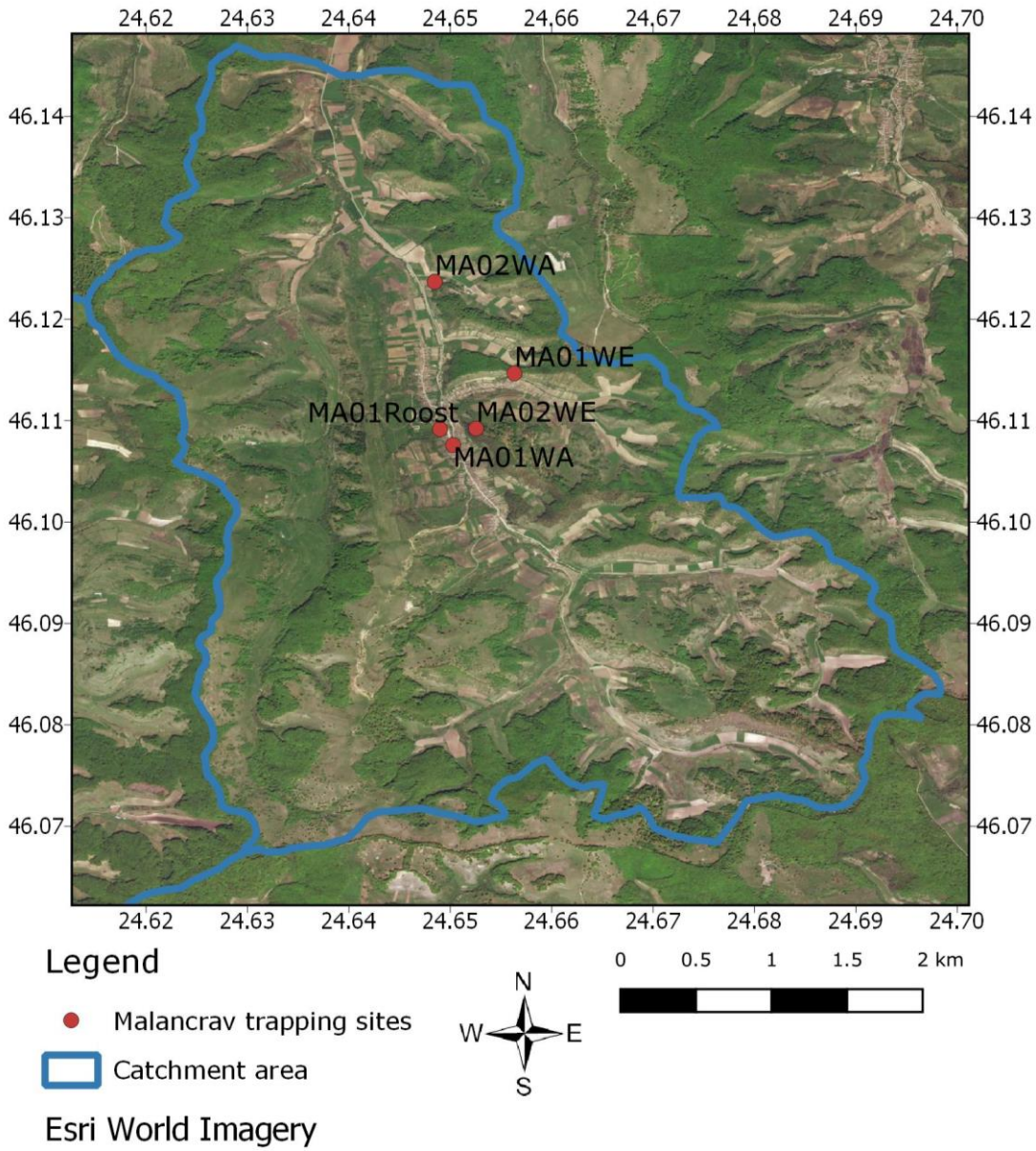

Figure 26. Malancrav catchment area and trapping sites.

Table 10. Summary of Apold trapping sites.

Site	Surveys	Effort (m^2nh)	Characteristics/Notes
AP01WA	1	570	Fishing pond, near major road
AP02WA	2	1763	Lake near woodland edge and grazed grassland
AP03WA	1	675	Fishing pond near woodland and reedbeds
AP01CH	1	877	Apold fortified church
AP01WE	1	720	Pine/Oak woodland, high clutter
Total	6	4605	

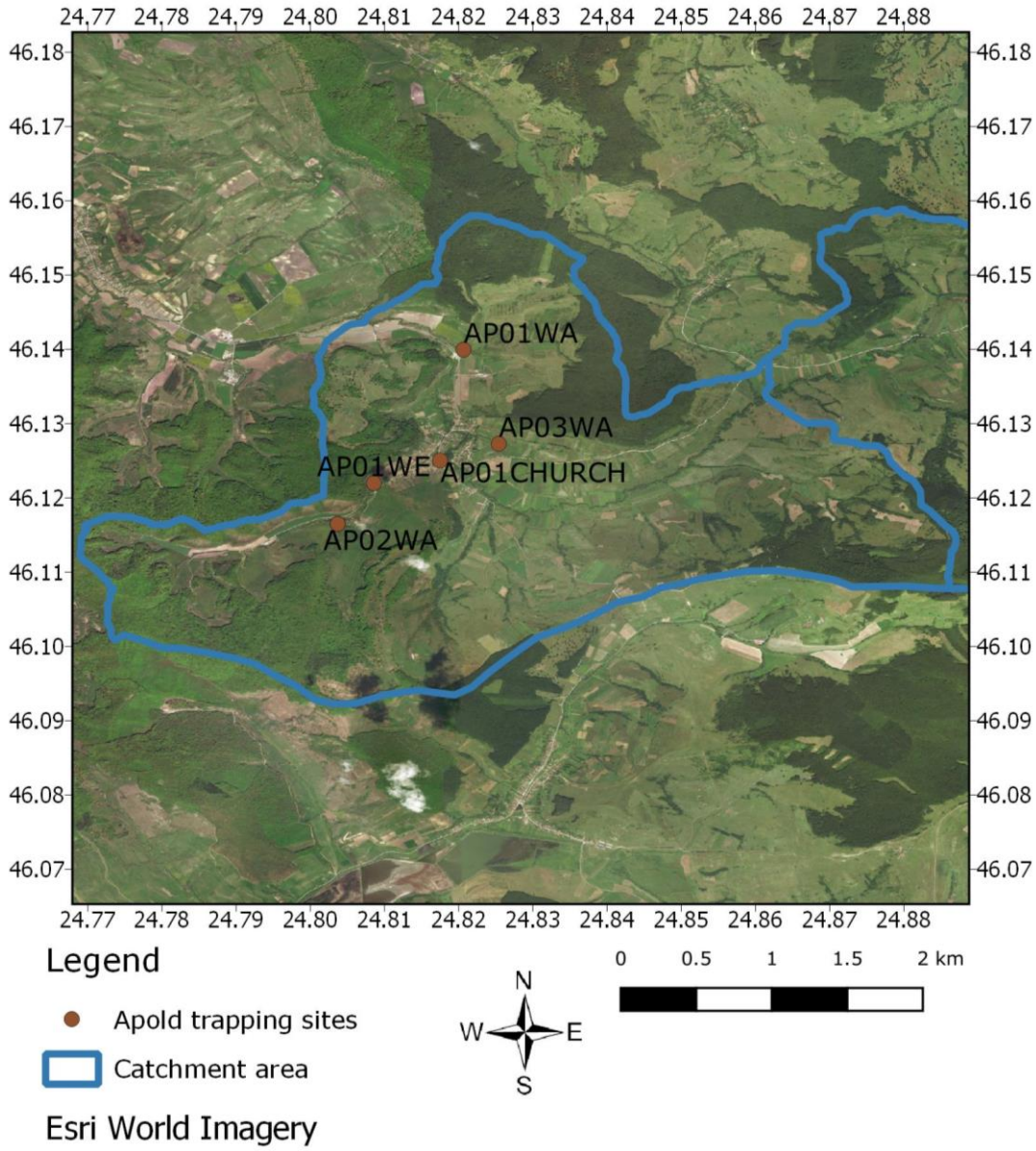

Figure 27. Apold catchment area and trapping sites.

Table 11. GPS location of survey sites in decimal degree format

Site Code	GPS North	GPS East
RI01WE	46.09268	24.49299
RI01WD	46.0863	24.49063
RI01WA	46.097257	24.480538
NS01WE	46.098321	24.604782
NS02WE	46.097715	24.606023
NS01PO	46.104944	24.606388
NSCHURCH01	46.113333	24.60466
MES01WA	46.086765	24.987347
MES02WA	46.084246	24.981574
MES01WE	46.092801	24.981509
MES02WE	46.09126	24.981433
MES01CHURCH	46.09061	24.97994
MES03WA	46.08433	24.98194
VI01WE	46.04864	25.06879
VI01WA	46.0589	25.10194
VI01Church	46.05494	25.08852
VI01WD	46.05247	25.06501
CR01WA	46.12092	25.01945
CR01Church	46.12347	25.01753
CR01WE	46.12303	25.00177
CR02WE	46.11507	25.00868
CR01Ur	46.12045	25.01733
MA01WE	46.11465	24.65631
MA01WA	46.10759	24.65027
MA02WA	46.12368	24.64846
MA01Roost	46.10915	24.64898
MA02WE	46.10921	24.65254
AP01WA	46.13995	24.82064
AP02WA	46.11649	24.80367
AP01CHURCH	46.12505	24.81747
AP01WE	46.12199	24.80855
AP03WA	46.12728	24.82538