

Acoustic bird monitoring – advantages and disadvantages

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Abstract

Globally, there are approximately 10,000 bird species, 75% of which have their habitat in forests. Forests provide essential resources necessary for life cycles, offering food sources, nesting sites or thermal refuges. But, in addition to the benefits brought to bird populations in forests, there are a number of threats to birds in managed forests. Well-designed monitoring programs can identify the decline of bird species populations, as it is known that birds can be used as indicators of biodiversity. Along with classical methods of bird monitoring, recently, automatic recorders are increasingly used. Through this article, we aim to present the acoustic monitoring method used to determine bird species in sample plots located in mixed stands (beech and sessile oak) both in managed forests and in the Runcu-Groși Natural Reserve. Thus, we used eight Song Meter Mini Bat recorders for the managed forest located in eight sample plots, and for the natural forest we used six Song Meter Mini Bat recorders and two Song Meter Mini Bat 2AA recorders located in another eight sample plots. The audio recorders were mounted on trees at a height of 2 m. The recorded sounds were analyzed using the Raven Pro and BirdNET Analyzer software. We also presented the advantages and disadvantages of this method.

Keywords: audio recorders, automated data collection, fauna survey, forests

Introduction

There are approximately 10,000 species of birds worldwide, ranging from the poles to the equator, from deserts to oceans, and from mountain forests to urban centers [29].

Forests are home to approximately 75% of bird species and are the primary habitat for most bird species [27].

Forests provide essential resources needed to complete their life cycles, including food for adults and young, as well as nesting sites. Birds are found at various trophic levels in forests; from primary consumers to predators, from omnivores to scavengers. Forests also provide nesting sites for birds. Nests can be found in all layers: from the ground, in shrubs, and up to the treetops [28].

Forests also provide wintering grounds, being important habitats for migratory birds on all major migration routes [12], where birds feed on insects and fruits and replenish their fat reserves used to cross seas or unforested habitats [19]. Forests provide thermal refuges when temperatures are physiologically difficult for birds, with birds seeking forested habitats in winter to be in an environment protected from winds, but also cool refuges when temperatures are high enough to cause heat stress in summer [28].

During the nesting season, the protection provided by the canopy can directly influence the development of chicks and can also influence reproductive success, at least for cavity-nesting birds [8].

Forest structure influences avian communities. Increased diversity of canopy height is associated with increased avian diversity, especially insectivores [13] and increased foraging habitats [14].

Just as forests influence bird populations, birds also influence forests. This interaction is both direct (e.g., seed dispersal) and indirect (e.g., consumption of phytophagous insects) [28].

But, in addition to the benefits brought to bird populations by forests, managed forests face a number of threats to birds: deforestation, habitat fragmentation and degradation, overexploitation, the emergence of invasive species and emerging infectious diseases, climate change, etc. [28].

Due to the increasing anthropogenic impact, 1012 species are subject to various types of threats [21].

A short-term solution could be forests (especially virgin forests) used as reserves to maintain biodiversity. Therefore, stands in the final stages of development should be a high priority [10].

Well-designed monitoring programs can identify declines in bird species populations early enough to facilitate the implementation of appropriate measures [15].

Classical bird monitoring methods using sample plots, strip transects, point counts, remote sampling or capture–mark–recapture can provide data indicating the diversity, composition, density and abundance of species in the study area [7]. Recently, however, automatic recorders are increasingly used to study birds [9].

They provide records that help identify species, records that can be independently reviewed and validated by several experts [22]. For this reason, and due to the lower costs and potential for greater standardization of methods, some researchers advocate the use of automatic recorders instead of expert personnel performing point counts [2].

The advantages of using birds as indicators of biodiversity and/or habitat quality in forest habitats are mainly based on (a) their relative ease of detection and (b) their strong association with many forest characteristics [1].

In this article, we aim to present the acoustic monitoring method used to determine bird species in sample plots located in mixed stands (beech and sessile oak) both in the managed forest and in the “Runcu-Groși” Natural Reserve, as well as the advantages and disadvantages of this method.

Material and Method

We used 16 automatic sound recorders in 16 sample plots, 8 of which were located in the Runcu-Groși Nature Reserve to monitor birds in a natural forest, and the other 8 were installed in the forest fund near the Conop locality to monitor birds in a managed forest.

We selected sample plots distributed in such a way as to represent the diversity of forest habitats: edges, interior, areas with mature trees, regenerative areas, areas with dead wood, areas with different types of microhabitats, areas with a mixture of forest species. Each plot was located with GPS to ensure repeatability and precise geographical documentation.

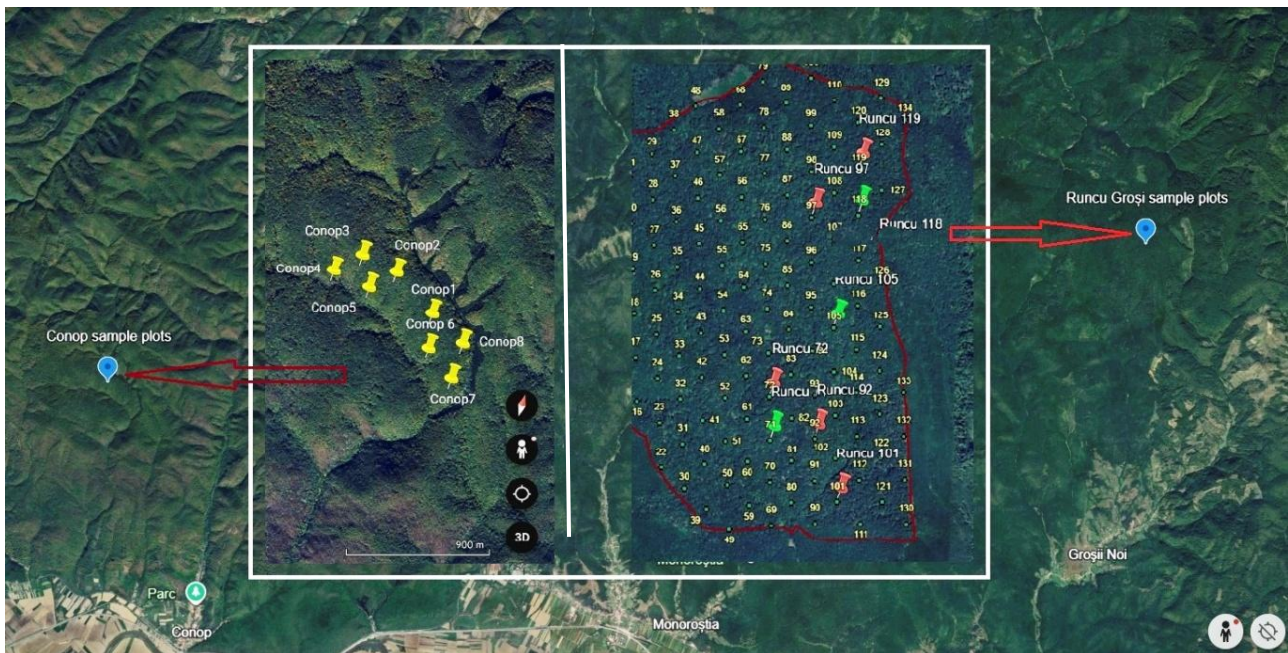


Fig. 1. The location of the sample plots in the managed forest and in the „Runcu-Groși” Nature Reserve [30]

The recordings were made with autonomous sound recording units with omnidirectional microphones Song Meter Mini Bat from Wildlife Acoustics. Although they are basically recorders used to capture ultrasounds produced by bats, they also have an acoustic recording option for bird sounds, an option that we also used. The recorders were mounted on trees in the centers of the sample areas at a height of about 2 meters to minimize background noise generated at ground level and to guarantee an effective acoustic coverage of the area of interest.

The recordings were made during a period that covers the bird breeding season, April-June, when vocal activity is maximum. The devices were programmed to make recordings throughout the day, between sunrise and sunset, an interval that corresponds to the peak moments of vocalizations, specific to the mating and raising periods of chicks. From a technical point of view, the devices have the capacity to capture sounds

with frequencies between 8 kHz and 96 kHz, in one-minute sequences. They are also designed to operate in various environmental conditions, withstanding temperatures between -20°C and $+85^{\circ}\text{C}$, which gives them high reliability in the field. Thanks to the batteries used, a total duration of approximately 250 hours of recordings per month was achieved for each device.

The audio data were downloaded periodically (every two weeks) and stored in a digital database. The identification of the vocalizations was carried out both manually, by listening and visual analysis of the spectrograms, and with the help of specialized bioacoustic analysis programs, such as BirdNET Analyzer and Raven Pro. For each identified vocalization, information was recorded regarding the species, time of emission, duration, signal intensity and exact location of the sound source.

Results and Discussion

One of the advantages of acoustic recorders is that they can sample significantly higher densities of birds than human point counts because birds are likely to be frightened away by human observers [5], and recorders are less likely to be perceived as a disturbance by birds than humans [6]. Sound recordings are also better suited to modelling distance sampling than point counts because they do not exhibit observer-induced avoidance and can easily collect multiple responses to obtain more accurate estimates of bird density [5]. Another advantage includes reduced human effort and the possibility of detecting nocturnal or cryptic species and obtaining valuable time series for population trend analysis [17].

In addition to the obvious advantages, acoustic recorders can also have a number of disadvantages. One of them is the degradation of the automatic recorder signal reception with increasing distance, which affects the ability of interpreters to visually distinguish bird sounds from background noise in the spectrograms of the recordings. Field analyses showed that the signal strength of recorded bird sounds was reduced by approximately 10 decibels at 40 m for recorders and microphones placed in protective containers compared to those that were not. Specialists also had great difficulty distinguishing bird sounds from background noise in spectrograms for distances of 80-100 m for recordings placed in protective containers. Also, experiments showed that the probability of detection was higher for point counts carried out by an experienced ornithologist than for the use of automatic recorders. Unfortunately, it can be costly and logistically difficult to find enough qualified ornithologists to support an annual point count program, especially for random locations in a large forested region that must be surveyed during the short breeding season when migratory birds are best detected by their song [11].

Manual analysis of acoustic data requires highly skilled ornithologists for the identification process, and accurate interpretation of the results requires a thorough knowledge of the ecosystems from which the data are collected [17].

A human observer can also visually detect birds at distances beyond the detection range of the sound recorder [6].

Another problem is posed by bird species with short or infrequent vocalizations. Birds such as woodpeckers or raptors are difficult to study based solely on acoustic cues and may therefore be better represented in human point data or other survey methods that include visual identification [26].

Habitat can also affect auditory detections through its influence on sound transmission and ambient sound levels due to insect noise, rustling leaves, wind, rain, or other water sources [6].

The quality of recordings also depends on the placement of microphones: those close to the ground place them in sound shadows [20], with detection ranges increasing with the height of the sound source, while microphones placed at higher heights will capture sounds from greater distances [4].

The use of at least two omnidirectional microphones oriented in opposite directions ensures the sampling of more birds by covering a larger sampling space and recording binaural cues, necessary for the localization of vocalizations [23], and the use of an even larger number of microphones (four channels) has produced some of the most efficient recording systems, allowing uniform coverage of the entire soundscape [3].

A major influence on sound quality is given by the signal-to-noise ratio. This is a defining characteristic of the microphone, which describes how faithfully a microphone records sound. Thus, increasing the signal-to-noise ratio of the microphone improves the probability of detection and identification by extending the detection range of the recording system [6].

For optimal results, specialists suggest recording audible sounds in uncompressed audio formats (sampling frequency: 44.1 kHz, WAV or FLAC audio file format), and microphones should be placed at a height of 1.5-2 m (i.e. a height similar to that of most human observers' ears) to maximize the sound detection space and avoid sound shadows [6]. Trees can be used as installation poles, but nevertheless, the microphones

should not be in direct contact with their trunk to avoid impeding sound transmission (a distance of 25 cm between the trunk and the recorder is sufficient) [16].

Audio recording installations can be configured in a variety of ways, they can be placed arbitrarily from above (in the tree crown using poles or even above the crown using drones [6].

Regarding the sampling method, specialists consider that high temporal resolution sampling of studies based on passive acoustic monitoring should be considered the main method for estimating the species richness of bird communities instead of low temporal resolution [17].

To establish the recording protocol, their vocal activity must be taken into account, activity that can vary throughout the year depending on the breeding season, migration periods, and their activity cycle (the peak of these cycles) [18].

Conclusions

Passive acoustic monitoring is an efficient, non-invasive and reproducible method for studying forest avifauna.

This type of monitoring requires a significant investment in both equipment and data management, which can often be difficult, compression and transfer operations can often take several days and require expertise in managing large volumes of data [18].

The analysis of the data resulting from the recordings often involves highly specialized personnel, who identify and annotate all or only a set of focal bird species present in the recordings, depending on the type of analysis that will be used: a trained detection algorithm or annotated raw data [25]. These approaches can be time-consuming.

In combination with appropriate statistical analyses, this technique can be used to assess species diversity, habitat use and community dynamics [11].

From the above, the usefulness of acoustic recorders as a long-term monitoring tool is confirmed, with applications in both biodiversity conservation and forest management [18]. However, combining traditional and autonomous survey techniques is desirable to obtain the best results in bird species inventory [24].

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References

- [1] Balestrieri, R., Basile, M., Posillico, M., Altea, T., De Cinti, B., Matteucci, G. (2015), *A guild-based approach to assessing the influence of beech forest structure on bird communities*. Forest Ecology and Management. 356.
- [2] Brandes, T. S. (2008). *Automated sound recording and analysis techniques for bird surveys and conservation*. Bird Conservation International 18:S163– S173.
- [3] Celis-Murillo, A., Deppe, J. L., Allen, M. F. (2009), *Using soundscape recordings to estimate bird species abundance, richness, and composition*. Journal of Field Ornithology, 80, 64–78.
- [4] Darras, K., Pütz, P., Rembold, K., Tschardtke, T. (2016), *Measuring sound detection spaces for acoustic animal sampling and monitoring*. Biological Conservation, 201, 29–37.
- [5] Darras, K., Furnas, B., Fitriawan, I., Mulyani, Y., Tschardtke, T. (2018), *Estimating bird detection distances in sound recordings for standardising detection ranges and distance sampling*. Methods in Ecology and Evolution. 9.
- [6] Darras, K., Batary, P., Furnas, B., Celis-Murillo, A., Van Wilgenburg, S., Mulyani, Y., Tschardtke, T. (2018), *Comparing the sampling performance of sound recorders versus point counts in bird surveys: A meta-analysis*. Journal of Applied Ecology. 55.
- [7] Whitworth, D., Newman, S., Mundkur, T., Harris, P. (2007), *Wild birds and avian influenza. An introduction to applied field research and disease sampling techniques*. FAO Animal Production and Health Manual No. 5
- [8] Dawson, R. D., Lawrie, C., C., O'Brien, E., L. (2005), *The importance of microclimate variation in determining size, growth and survival of avian offspring: experimental evidence from a cavity nesting passerine*. Oecologia, vol 144, no 3, pp. 499–507.
- [9] Depraetere, M., S. Pavoineb, F. Jiguet, A. Gasca, S. Duvailld, and J. Sueura. (2012), *Monitoring animal diversity using acoustic indices: implementation in a temperate woodland*. Ecological Indicators 13:46–54.
- [10] Franklin, J., F. (1993), *Preserving Biodiversity: Species, Ecosystems, or Landscapes?* Ecological Applications, 3 (2), 202-205

- [11] Furnas, B., Callas, R. (2014), *Using Automated Recorders and Occupancy Models to Monitor Common Forest Birds Across a Large Geographic Region*. The Journal of Wildlife Management. 79.
- [12] Kirby, J., S., A., J. Stattersfield, S., H., M., Butchart, M., I., Evans, R., F., Grimmett. A. (2008), *Key conservation issues for migratory land- and waterbird species on the world's major flyways*. Bird Conservation International, vol 18, pp. S49-S73.
- [14] MacArthur, R., H. Recher M. Cody. (1966), *On the relation between habitat selection and species diversity*. American Naturalist, vol 100, pp. 320–332.
- [15] MacLeod, C. J., Greene, T., C. MacKenzie, D., I. Allen. R., B. (2012). *Monitoring widespread and common bird species on New Zealand's conservation lands: a pilot study*. New Zealand Journal of Ecology 36:1– 12.
- [16] Maxon, A., B. Mazor, M. (1977), *The effects of microphone spacing on auditory localization*. Audiology, 16, 438–445.
- [17] Metcalf, O., Barlow, J., Marsden, S., Moura, N., Berenguer, E., Ferreira, J., Lees, A. (2021), *Optimizing tropical forest bird surveys using passive acoustic monitoring and high temporal resolution sampling*. Remote Sensing in Ecology and Conservation. 8.
- [18] Molina-Mora, I., Ruiz-Gutierrez, V., Vega-Hidalgo, Á., Sandoval, L. (2024), *The utility of passive acoustic monitoring for using birds as indicators of sustainable agricultural management practices*. Frontiers in Bird Science. 3.
- [19] Moore, F., Kerlinger. P. (1987), *Stopover and fat deposition by North American wood-warblers (Parulinae) following spring migration over the Gulf of Mexico*, Oecologia, vol 74, no 1, pp. 47–54
- [20] Morton, E., S. (1975), *Ecological sources of selection on avian sounds*. American Naturalist, 109, 17.
- [21] Owens, I., P., F. Bennett, P., M. (2000), *Ecological basis of extinction risk in birds: Habitat loss versus human persecution and introduced predators*.
- [22] Rempel, R., S., Hobson, K., A., Holborn, G., Van Wilgenburg, S., L., Elliott, J. (2005), *Bioacoustic monitoring of forest songbirds: interpreter variability and effects of configuration and digital processing methods in the laboratory*. Journal of Field Ornithology 76:1–11.
- [23] Rempel, R., S., Francis, C., M., Robinson, J., N., Campbell, M. (2013), *Comparison of audio recording system performance for detecting and monitoring songbirds*. Journal of Field Ornithology, 84, 86–97.
- [24] Robinson, W., D., Curtis, J., R., (2020), *Creating benchmark measurements of tropical forest bird communities in large plots*. Condor, 122(3)
- [25] Sugai, L., S., M., Silva, T. S. F., Ribeiro, J. W. Jr., Llusia, D. (2019), *Terrestrial passive acoustic monitoring: review and perspectives*. BioScience 69, 15–25.
- [26] Sedláček, O., Vokurková, J., Ferenc, M., Djomo, E. N., Albrecht, T., Hořák, D. (2015), *A comparison of point counts with a new acoustic sampling method: A case study of a bird community from the Montane forests of Mount Cameroon*. Ostrich, 86, 213–220.
- [27] Şekercioğlu, Ç., H., Daily, G., C., Ehrlich, P., R. (2004), *Ecosystem consequences of bird declines*. Proc Natl Acad Sci USA, vol 101, no 52, pp. 18042–7.
- [28] Stratford, J., Sekercioglu, C. (2015), *Birds in Forest Ecosystems*.
- [29] Tabur, M., Ayvaz, Y. (2010), *Ecological Importance of Birds*.
- [30] <https://earth.google.com/web/>