Acoustic bird monitoring in 20 Swiss agroforestry systems: Challenges and opportunities

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Introduction

Modern agroforestry is emerging in Switzerland. One example is the project Agro4esterie, which aims to promote agroforestry in four cantons of western Switzerland. Farmers are supported in the establishment of new agroforestry systems. Starting in 2020, with around 100 farmers participating, both new silvoarable and silvopastoral agroforestry systems were installed. From 2020 to 2027 a biodiversity monitoring is being carried out on 20 sites (Roberti 2023).

Trees and shrubs in open farmland can provide additional habitats for breeding birds, and thus agroforestry systems may help in restoring farmland bird diversity, especially in temperate Europe (Edo et al. 2023). Our research focuses on monitoring methods for this species group using digital audio recorders and deep-learning-based tools. These techniques of analyses are emerging as a new way to perform monitoring (Pérez-Granados 2023). Passive acoustic monitoring is the deployment of audio recording devices to capture, in this case, vocalizations of birds. These sounds can be analysed by the deep-learning-based tool BirdNET, which is able to detect more than 6000 species worldwide (Kahl et al. 2021). BirdNET output consists of timestamps, with species names and a confidence value indicating the certainty of the model with its prediction.

Research questions

The technical and ecological aspects encountered in the ongoing monitoring lead to two key questions:

- How good is the quality of the automated detection with audio-recording techniques in combination with BirdNET?
- Can we already find patterns in breeding bird diversity in young agroforestry systems after two years of monitoring?

Methodology

We used the AudioMoth recorder (Hill et al. 2019) for our audio recordings. As part of the monitoring on 20 sites, passive acoustic monitoring in combination with a semi-automatic analysis workflow is being used to quantify breeding bird diversity. During three weeks per year (April, June, August), daily recordings are made (2h each day, starting at sunrise) and subsequently audio files are analysed using the application BirdNET.

On a subset of 28 recording sequences, five different procedures for filtering of the BirdNET output data are applied, using a combination of species lists and confidence threshold. The confidence threshold filter excludes detections below a value of 0.5 (in a range of 0 to 1), and the species list filter excludes species not represented in an expert species list. The same 28 recordings were annotated by an ornithologist for comparison.

For the analysis of the entire recording dataset, a combination of a confidence threshold of 0.5 and a local species list is used. Manual verification of detections is performed in uncertain cases.

Results

The comparison of the five analysis procedures shows that procedures using a confidence threshold have a high number of false negative detections, but a very low number of false positives. On the other hand, species lists have the reverse effect (little false negatives, high number of false positives). True positives are high using species lists, and low for confidence value procedures. Looking at the F1-Score, using a local species list without confidence threshold, performs best (F1 of 0.3)

The dataset from the initial years of the monitoring gives some insight into breeding bird diversity in emerging agroforestry systems. On average, 8.5 species were found on the monitoring sites. Bird diversity correlates with the amount of bird habitats expressed as a habitat score (Kaeser 2009) in the vicinity of the site (see appended figure). However, no clear effect of farming intensity (organic vs. conventional farming) nor type of agroforestry system (silvopastoral vs. silvoarable) on bird diversity was observed. Since the trees are still very young (<5 years) the environmental effects of the agroforestry systems might not be very strong yet.

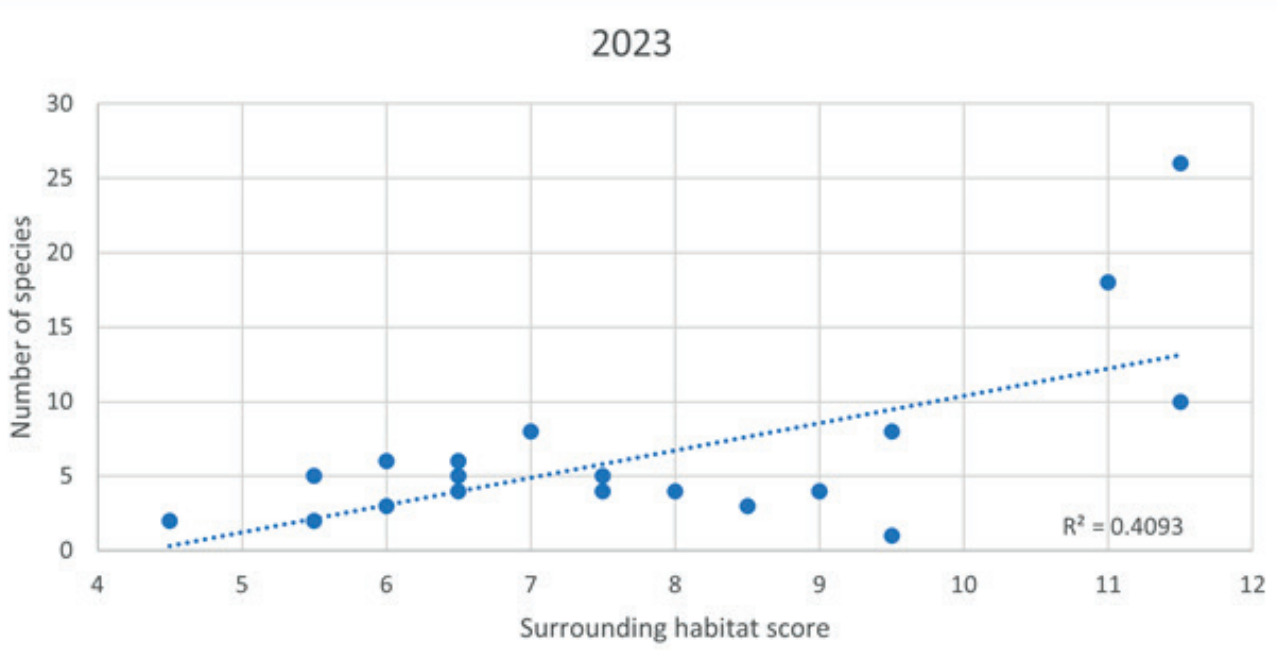
Conclusion

In conclusion, passive acoustic monitoring seems to be a suitable and effective method for assessing bird diversity in agroforestry systems. The analysis workflow allows for a time-efficient monitoring, but some challenges in regards to reliability and technical complexity remain. The data from the environmental monitoring reveals interesting correlations and can help to understand the impact of Swiss agroforestry systems on birds. However, further monitoring is needed to get a clearer picture on the longer-term effects.

Keywords

Birds, Agroforestry system, agroforestry monitoring, deep learning, passive acoustic monitoring, agri-environmental system, biodiversity, Audio recordings

Aditional Attachment II.



Bibliography

Edo M, Entling MH, Rösch (2024) Agroforestry supports high bird diversity in European farmland. Agronomy for Sustainable Development. http://dx.doi.org/10.1007/s13593-023-00936-2

Hill AP, Prince P, Snaddon JL, Doncaster CP, & Rogers A. (2019) AudioMoth: A low-cost acoustic device for monitoring biodiversity and the environment. HardwareX, 6. https://doi.org/10.1016/j.ohx.2019.e00073

Kaeser A (2009) Agroforstwirtschaft zur Förderung der Artenvielfalt: Erarbeitung eines Schlüssels zur Bewertung des Naturschutzpotenzials und Anwendung an drei Fallbeispielen im Schweizer Mittelland. Master's Thesis. Eidgenössische Technische Hochschule Zürich, Departement Umweltwissenschaften. https://doi.org/10.3929/ethz-a-006050249

Kahl S, Wood CM, Eibl M, Klinck H (2021) BirdNET: A deep learning solution for avian diversity monitoring. Ecological Informatics. https://doi.org/10.1016/j.ecoinf.2021.101236

Pérez-Granados 2023 (2023) BirdNET: applications, performance, pitfalls and future opportunities. Ibis 2023. https://doi.org/10.1111/ibi.13193

Roberti G, von Pfeil C, Kunzelmann J, Funke L, Rutz T, Kay S (2023) Leitfaden für das Monitoring von Agroforst-Systemen. Agroscope Transfer. https://link.ira.agroscope.ch/de-CH/publication/52503. Accessed on 03 January 2024