Mini Research Note Bioacoustics for Raptor Research

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Forest harvesting practices can have influences on the biodiversity of forest ecosystems through altering the natural disturbance regimes, forest structure and age composition (Lindenmayer et al. (2000)). Since the 1990s in central Europe there has been a shift from clear-cutting toward retention forestry (also often referred to as a "close-to-nature" approach), which focuses on selective harvesting of individual trees or groups of trees while retaining elements of forest structure that support biodiversity and ecosystem services (Bastrup-Birk et al. (2016)). Retention forestry generally attempts to maintain structural and functional diversity through the retention of habitat trees (typically large and old) and standing and fallen deadwood, while still having a net economic benefit. Monitoring biodiversity in forests subject to differing harvest practices has been done using a variety of indicator animal species and guilds, with a host of reliability issues (Basile et al. (2020)), suggesting the situation is often complex and nuanced.

Forests in central Europe will be subject to new threats in the coming decades (e.g., bark beetle, drought, and climate change) and are likely to experience large-scale changes and increased harvest pressure (Bastrup-Birk et al. (2016)). To protect species that rely on forests, it is important that we assess the needs of those species before their habitats are threatened or lost, to be able to best inform future management decisions. While it is important to understand how biodiversity as a whole is changing, it is also important to understand species- and region-specific responses to harvesting (figure ??).

With the advances in technology in recent years, monitoring biodiversity through the use of autonomous acoustic recording units (ARUs) has become more prevalent and practical for researchers in a range of fields (e.g., bats,
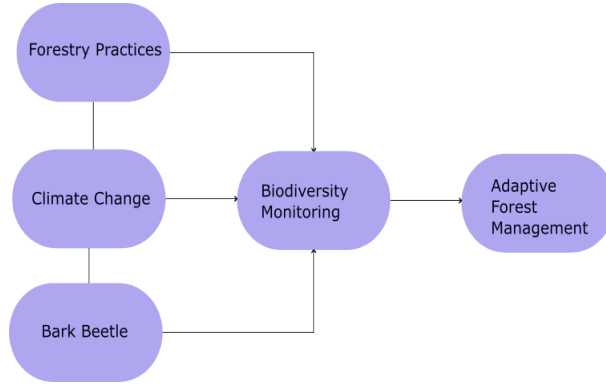
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Figure 1: Biodiversity monitoring and adaptive forest management are key to sustainable future forests.

birds, insects, mammals). Bioacoustics is a field of biological study that integrates sound technology to record, store, and analyze acoustic animal communication (Penar et al. (2020)). Some recent work shows that bioacoustic indices of bird diversity reflect results of traditional field surveys (e.g., point counts) and can be used to support and improve indices of bird diversity created from only field methods (Shaw et al. (2024); Pérez-Granados and Traba (2021)). Bioacoustics can also be used as a tool for monitoring species of management interest or conservation concern. It is particularly suited to species that are difficult or impractical to detect using traditional field methods, such as raptors (i.e., birds of prey; Kramer et al. (2024); Shonfield et al. (2018)).

Raptors (hawks/eagles, owls, falcons, vultures) are a unique bird guild: charismatic, but also potentially threatening to, or feared by farmers and hunters (Sergio (2018)). They generally feed on a variety of prey and can have large home ranges, making them difficult to study and locate during field surveys (McClure et al. (2018)).

Standard field survey methods for raptors are generally time- and resource-intensive, for example using transect surveys, call playbacks, and migration surveys. These methods can have limited success due to many species having generally elusive habits, i.e., wide ranges, infrequent vocalization rates, and low density populations (McClure et al. (2018)). Despite these challenges in standard methods, raptors have seen little representation to date in the bioacoustics field (e.g., Demarco (2020); Kramer et al. (2024); Shonfield et al. (2018)). While I foresee bioacoustics as a way to improve raptor monitor-

ing, their elusive nature will likely still be a limiting factor in point-based monitoring and research, such as the methods employed in this study.

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