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RESEARCH ARTICLE

Restoration of boreal wetlands increases bat activity

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Wetlands are important habitats for insectivorous bats, as the presence of water promotes insect abundance and provides drinking water for wildlife, and therefore could promote bat conservation. Research on bats and wetlands has mainly focused on constructed wetlands, and with a geographical emphasis on eastern United States and central Europe, whereas relatively little is known about the effects of wetland restoration on bats, especially in the boreal zone. We conducted a Before-After-Control-Impact (BACI) study in 21 wetlands. Using acoustic survey techniques, we collected information on bats both before and after restoration, with 7 of the 21 wetlands acting as control sites and 14 as impact (i.e., restored) sites. Acoustic surveys were conducted in May–September in the years 2018, 2019 (before restoration) and in 2021 and 2022 (after restoration). Species detection for each night was assessed by automated analysis of audio recordings. We assessed the presence and number of active minutes of the Northern bat (*Eptesicus nilssonii*) and the *Myotis* species group, using a generalized linear mixed model. Wetland restoration increased the acoustic activity of both taxa, but not their presence. Thus, restoration increased the usage of wetlands as a feeding site for bats. Our BACI study provides strong evidence that wetland restoration caused an increase in bat activity, and can be used as an effective tool for bat conservation.

Key words: bat conservation, boreal bat, boreal wetland, Finnish bat, Finnish wetland, wetland restoration

Implications for Practice

- Ditch plugging and tree felling for peatland restoration purposes avail bats as it improves prey availability and facilitates foraging opportunities.
- The benefit of wetland restoration for bats should be understood as improving landscape-level suitability by increasing habitat heterogeneity.
- Landscape connectivity and low aquatic vegetation cover may be important predictors of bat habitat use post wetland restoration in the longer term.

Introduction

Wetlands are simultaneously one of the most important and threatened types of ecosystems (Hu et al. 2017; Xu et al. 2019). For instance, they host high biodiversity, are part of the water cycle, provide ecosystem services to humans, and stabilize shorelines. They play an essential role against global climate change by acting as buffer zones against sea level change, or constituting water reserves in case of drought (Ramsar Convention Bureau 2001; Erwin 2009). Despite their importance, wetlands have endured a dramatically high rate of destruction and degradation, for example, through drainage, pollution, and eutrophication, impeding their various roles and capacities (Xu et al. 2019; Fluet-Chouinard et al. 2023). The conservation of intact wetlands is critical, but as more than 33% of these ecosystems have already been lost (Hu et al. 2017; Fluet-Chouinard et al. 2023), actions aimed to restore or construct wetlands are also needed.

Wetlands are prominent features of the boreal zone. For example, in Finland, wetlands cover about 15% of the country's total area (Corine Land Cover data 2018). Wetland ecosystems have been put under enormous pressure in the past, through exploitation of peat and drainage for transformation into arable lands or commercial tree plantations (Strack 2008; Norstedt et al. 2021). Consequently, research on wetland restoration and drainage in the country is substantial, with a focus more on hydrology than biodiversity (Bring et al. 2022).

One role of wetlands is to provide services to bats: permanent water in wetlands favors the development and abundance of multiple insect species, on which numerous bat species feed, and of other prey such as fish (Salvarina 2016; Mas et al. 2021). Wetlands are also a source of drinking water for bats, and can offer roosting opportunities for some species through the presence of decaying trees (Salvarina 2016). The importance of wetlands for bats is not only restricted to the temperate climate: from the Amazon to arid environments, presence of water is crucial for bats (Bader et al. 2015; Blakey et al. 2018;

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Torrent et al. 2018). Consequently, their destruction, and the deterioration of their quality, will impact bats. Heavy metal pollution, pesticides, eutrophication, light pollution, habitat loss, and fragmentation are only a few of the threats that have been reported to negatively impact the richness and activity of bat communities in these habitats (Lookingbill et al. 2010; Korine et al. 2016; Straka et al. 2016). Conservation of wetlands, and related efforts of construction and restoration of these ecosystems may aid conservation of bats.

Despite the potential importance of wetland restoration and construction for bats, relatively few studies have been conducted on this topic (Fig. 1). Moreover, the majority of these studies only monitor bats after the restoration work, comparing restored sites to nonrestored sites (but see Menzel et al. 2005 for an exception). To demonstrate that the restoration action caused the observed difference, a comparison of presence and activity of bats prior to the restoration action is needed. Irrespective of this shortcoming, most research—mainly conducted on wetlands that have been drained and overgrown by woodlands—shows that in sites where drainage ditches are plugged and trees are felled, restored wetlands host more diverse bat communities than other habitats (Menzel et al. 2005; Allagas 2020; Snyder 2022). With restoration actions, habitats were opened and the presence of water became a permanent feature as a result of rising water levels, leading to a greater availability of food. Apart from restored wetlands, research has also been conducted on constructed wetlands, that is, wetlands built on sites where no wetland has been recorded in the past, including water bodies built for other purposes, such as retention ponds (Fig. 1). High bat activity has also been recorded at these sites, showing that they could also have an important role in bat conservation (Beranek et al. 2021; Li et al. 2021).

Here, we provide baseline information regarding the effects of wetland restoration on bat presence and activity in Finland and more broadly in the boreal zone. The restoration effort is part of the Hydrology LIFE project, a mission partly funded by the European Union to restore peatlands in Finnish Natura 2000 areas (Metsähallitus 2023). Using a Before-After-Control-Impact (BACI) sampling scheme, we monitored bat acoustic activity at control and restored sites from 2018 to 2022. Based on literature on wetland restoration, we expected the presence and activity of bats to increase once ditches were plugged and trees felled, creating better foraging and roosting conditions for all species.

Methods

Sampling Design

We monitored bat acoustic activity with passive recorders and using a BACI design (Green 1979), meaning that monitoring took place before and after the restoration work at both restoration and control sites. Our study design allowed discrimination between the expected spatial and temporal variation in bat presence and activity, and the effect of the restoration actions.

Figure 1. Location of studies monitoring bat activity in restored, constructed, or drained wetlands. Studies on actual restoration of wetlands are very limited (green dots; Menzel et al. 2005; Allagas 2020; Snyder 2022), most work having been carried on constructed wetlands (orange triangles; Flaquer et al. 2009; Maslonek 2010; Ciechanowski et al. 2011; Stahlschmidt et al. 2012; Korine et al. 2015; Straka et al. 2016; Parker et al. 2019; Toffoli & Rughetti 2020; Beranek et al. 2021; Li et al. 2021), while one study investigated the effects of drainage (red diamonds; Vindigni et al. 2009).

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The original plan was to carry out most of the restoration work in 2020. We designed the monitoring to cover years 2018–2019 ("Before" years) and 2021–2022 ("After" years), while 2020 was left without monitoring. However, because of practical and logistical reasons, on different sites the restoration was conducted over different years (Table S1). This resulted in some sites having more "Before" years than "After" years and vice versa.

Study Sites

There were 21 monitoring sites, of which 14 were restoration sites and 7 control sites. We grouped the 21 sites in 10 areas (Table S1; Fig. 2). Both restored and control sites were located in Natura 2000 protected areas. Not all areas had a control site due to the limited number of detectors available and the often-restricted size of the Natura 2000 areas (mean = 8.42 km^2 when located outside of national parks, 33.7 km^2 in national parks). Consequently, control sites were mainly located in large Natura 2000 areas (over 12 km^2), which often coincided with national parks. In these large Natura 2000 areas, there were two to four monitoring sites within each area, otherwise there was a single monitoring site per Natura 2000 area. We installed one detector at each monitoring site.

In a given Natura 2000 area, the control site and the restoration sites were located in similar habitats. We chose monitoring sites to represent different types of (restored) peatlands. Because of the role of woodlands for several species of bats during the boreal summer, we set most of our detectors in such habitats, while a few were located in open and semi-open areas (Wermundsen & Siivonen 2008; Vasko et al. 2020). All chosen woodlands were typical of the European boreal region, with old spruce or mixed forests of pine, spruce, and birch, and often located near wetlands like bogs or ponds (Sundseth 2009).

To reflect these differences at our sites, we quantified tree cover in the area surrounding the detectors by estimating the proportion covered by tree canopy there (Vasko et al. 2020). We separated our sites in three classes: (1) open bog with few trees; (2) forest with openings; and (3) dense forest where openings are limited to ditches. We also assessed soil productivity at our sites, using Ellenberg indicator values, as a way to predict insect abundance, with high soil productivity a synonym of higher insect abundance (Ellenberg et al. 1991; Vasko et al. 2020). Finally, using GIS (QGIS software, version 3.4) we measured distance to the closest permanent open water bodies, regardless of their size, because of their importance to all bat species, either for drinking or foraging (Wermundsen & Siivonen 2008; Vasko et al. 2020).

The objective of restoration being to return drained peatlands to their predrainage state, restoration work consisted of ditch plugging and tree felling. The former allows water levels to rise permanently, while the latter leads to the natural open state of these habitats. At our restored sites, all ditches were plugged, while the number of trees felled varied from site to site. At some

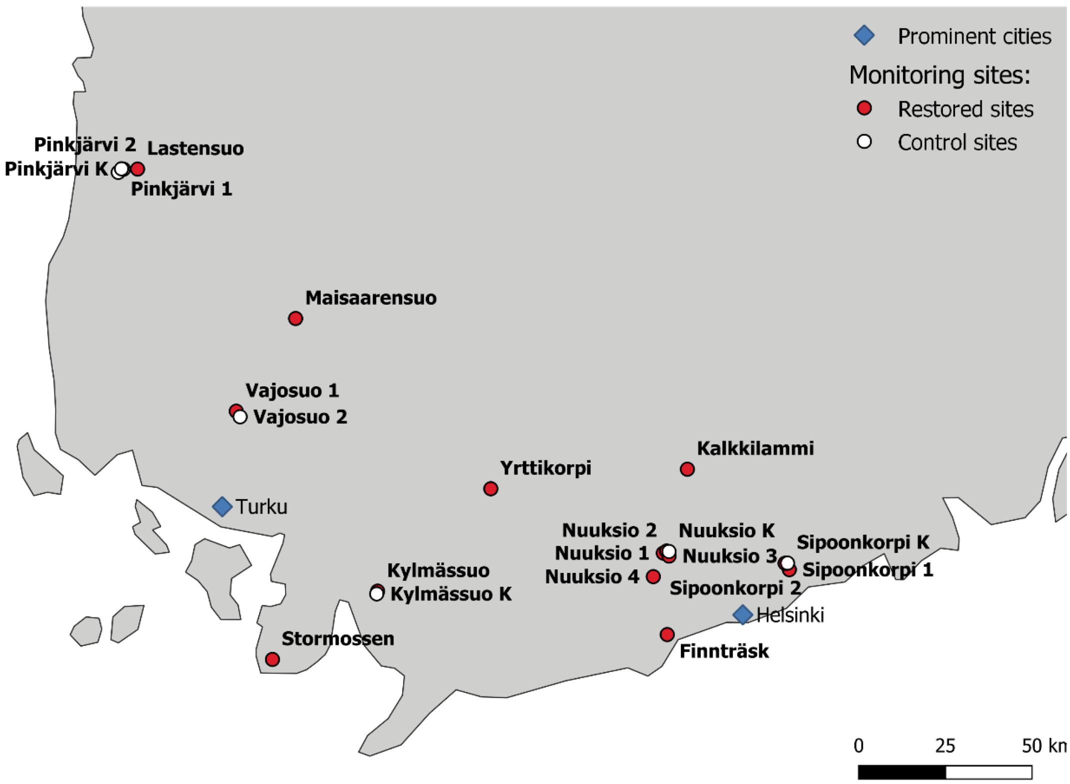

Figure 2. Bat monitoring sites in southwestern Finland. Prominent cities are indicated with a blue diamond. Restored sites are indicated with a red dot, control sites with a white one. See Table 1 for an overview.

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sites, tree felling was limited to the necessary to allow the excavator to plug the ditches, while at other sites such as Lastensuo or Vajosuo 1, more trees were felled to create more open habitats. Ditch plugging usually took 1 or 2 days, but some time could pass between tree felling and ditch plugging at one site.

For each site, restoration action that took place between January and September is considered to affect bats the same year, and the bat recordings of this year were classified as "after" restoration. Restoration action conducted between October and December is considered to affect bats only the year after, and only the recordings from the next monitoring period will be treated as "after" restoration. For instance, bat activity of 2020 will be considered "after" the restoration if the restoration happened between January and September 2020 (Table S1).

Acoustic Monitoring

We used ultrasonic passive recorders (SongMeter SM4, Wildlife Acoustics) with SMM-U1 microphones (Wildlife Acoustics) to record bat echolocation calls at monitoring sites. We programmed the devices to record every night, from dusk until dawn, between 1 May and 30 September. We changed the batteries and memory cards once per month. We placed the detectors 5–15 m from ditches to avoid the units being damaged during ditch plugging. We placed the microphones 1.5–2 m above the ground level. Sample rate of the recorders was 256 kHz, trigger level 12 dB and trigger window 2.0 seconds, minimum duration 1.0 microseconds, and minimum trigger frequency 16 kHz.

In one detector/microphone pair there were more severe problems causing noise files to dominate the recordings rendering the data for the entire season useless. This happened twice and was not noticed before analyzing the data after the season (Maisaarensuo in 2019 and Vajosuo 2 in 2022).

Acoustic Calls Analyses

We analyzed the data using SonoChiro (version 4.1.4, Biotope), a program which automatically classifies recordings into species and provides an index of reliability for the classification. Working parameters on SonoChiro were the following: Nord Boreal classifier, minimum frequency of 10 kHz, maximum of 140 kHz, call duration of 0.5 microseconds, 2 pulses required, with highest sensitivity. Because *Eptesicus nilssonii* (northern bat) and *Myotis* spp. are very common in SW Finland, and their identification by SonoChiro is reliable (5% of the files were verified), we did not use a cut-off level nor did we manually verify all our observations of those groups. We grouped four *Myotis* species (*M. brandtii*, *M. daubentonii*, *M. mystacinus*, and *M. nattereri*) occurring in the data into *Myotis* spp. because these cannot be reliably distinguished apart neither by the program nor manually. Files containing other species were all manually checked, with the exception of *Pipistrellus nathusii* files at Finnträsk site, more abundant, of which only a sample of them were verified.

Statistical Analyses

We focused on monthly metrics to take into account seasonal variation. In addition, there were technical problems causing some of the detectors to not record full time between visits (e.g., microphone breaking, running out of space on memory cards). Therefore, analysis of monthly metrics took into account the actual numbers of recording nights. We used two metrics to quantify bats: (1) Presence; for each month the number of nights with one or more detections of a species group was computed. The probability of presence is hence the number of nights detected relative to the number of nights the detector was operational for each month. (2) Activity; the number of minutes (defined by the time stamp) with at least one detection of a species per night was computed. We refer to these minutes as active minutes.

We analyzed both presence and activity of a species group using generalized linear mixed model (GLMM). For presence, we used a GLMM with binomial errors and logit link. As fixed effects, we included month (as a factor), year (as a factor), whether the data were from before or after restoration (Before or After), the restoration action (Control or Impact), tree cover (as factor), distance to water (less than 1 km away = Yes, more than 1 km away = No), soil productivity (as factor), and the interaction between Before/After categorization and restoration action. For control sites, sites were categorized as "before" for recordings made before 2020 and as "after" for recordings made after 2020. For impacted (i.e., restored) sites, categorization as "before" or "after" follows the actual timing of the restoration action (Table S2). As we used a BACI design, the critical aspect is whether the interaction between "before-after" and "control-impact" shows statistical significance. For activity, we used a

Table 1. Descriptive statistics of the presence and activity of the two most commonly detected species groups. For each year, the number of sites and number of nights recorded in May–September in all sites are denoted together with the number of nights during which one or more *Myotis* spp. and *Eptesicus nilssonii* were detected, as well as the total number of active minutes for each species group. Whether a bat species group was detected during a night is used as a measure of presence. An active minute for each minute of recording scores whether one or more calls of the bat species group was detected and is used as a measure of activity. Note that recordings were not obtained in one site in 2019 and 2022.

Year	*Number of Sites*	*Number of Nights Recorded*	*Number of Nights with* Myotis *spp.*	*Active Minutes of* Myotis *spp.*	*Number of Nights with* E. nilssonii	*Active Minutes* of E. nilssonii
2018	21	2,534	2,119	44,714	1,634	16,324
2019	20	2,778	2,208	38,139	1760	20,793
2021	21	2,270	2007	68,996	1777	34,090
2022	20	2,849	2,585	108,740	2017	41,536
All years		10,441	8,919	260,589	7,188	112,743

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GLMM with negative binomial errors and log link. As fixed effects we included the same effects as for presence and additionally the number of nights recording per month was included after standardizing it to zero mean and unit standard deviation. In all models we included area and site as random effects to account for spatial nonindependence (area) and repeated measures (site). We implemented all GLMMs in the R package glmmTMB (Brooks et al. 2017) in the program R (R Core Team 2023, version 4.2.2.). Statistical significance of variables with one or more parameters was evaluated through Wald tests, which are based on comparing the estimated parameter(s) value and its uncertainty against zero and which follow a chi-square distribution with the associated probability value providing the probability the parameter(s) of interest are statistically equal to zero (Bolker et al. 2009).

Results

Data Collected

The *Myotis* spp. group and *E. nilssonii* were the most common species groups at the sites studied. *Myotis* spp. and *E. nilssonii* were present in over 85% (8,919/10,441) and 69% (7,188/10,441) of our recorded nights, respectively (Table 1). Both species groups were also very active as enumerated by the number of active minutes (Table 1). In addition, Nathusius' pipistrelle (*Pipistrellus nathusii*) was recorded, although mainly at a single restored site, and the species was more active after restoration than before (Table S3). There were a few hundred recordings of long-eared bats (*Plecotus auritus*) and individual recordings of noctule bats (*Nyctalus noctula*), soprano pipistrelles (*Pipistrellus pygmaeus*), and parti-colored bats (*Vespertilio murinus*) (Table S3). For statistical analyses, however, we focus on the two most common species groups.

The restoration of wetlands was planned to take place in 2020, and mostly progressed according to schedule (Table S2). Two sites with recordings where wetlands were restored already in 2019 and three sites with recordings where wetlands were not yet restored in 2021 (Table S2) were exceptions. All 14 wetlands were restored by 2022.

Is the Presence of Bats Affected by Wetland Restoration?

The presence of *Myotis* spp. and *E. nilssonii* was high both during the period before and after restoration in both control and impacted sites (Fig. 3). There was no evidence that wetland restoration changed the presence of these bat species groups (Tables S4 & S5). For *Myotis* spp., presence was only affected by months (chi-square = 42.03, $df = 4$, $p < 0.001$; Table S4). For *E. nilssonii*, in addition to monthly differences (chi-square = 368.77, $df = 4$, $p < 0.001$), there were also significant differences in presence across habitats, with higher probability for *E. nilssonii* presence at sites with intermediate tree cover (chi-square = 6.93, $df = 2$, $p = 0.03$) and open water nearby (chi-square = 7.65, $df = 1$, $p = 0.006$; Table S5).

Is the Activity of Bats Affected by Wetland Restoration?

In both species' groups, activity varied across months, and for *Myotis* spp. only, across years too (Tables S6 & S7). Higher soil productivity increased the activity of *Myotis* spp. (chi-square = 8.2, $df = 2$, $p = 0.017$; Table S6) and the proximity to open water increased the activity of *E. nilssonii* (chi-square = 14.87, $df = 1$, $p < 0.001$; Table S7). The activity of *Myotis* spp. was higher during the period after restoration than before in both control and impact sites (Tables S6 & S7; Fig. 4). Activity of both groups increased relatively most in impacted (i.e., restored) sites compared to nonrestored (i.e., control) sites (interaction in Tables S6 & S7; Fig. 4). For *Myotis* spp.: chi-square = 17.4, $df = 1$, $p < 0.001$; for *E. nilssonii*: chi-square = 6.26, $df = 1$, $p = 0.01$. Thus, there was a positive effect of wetland restoration action on activity in both bat species groups.

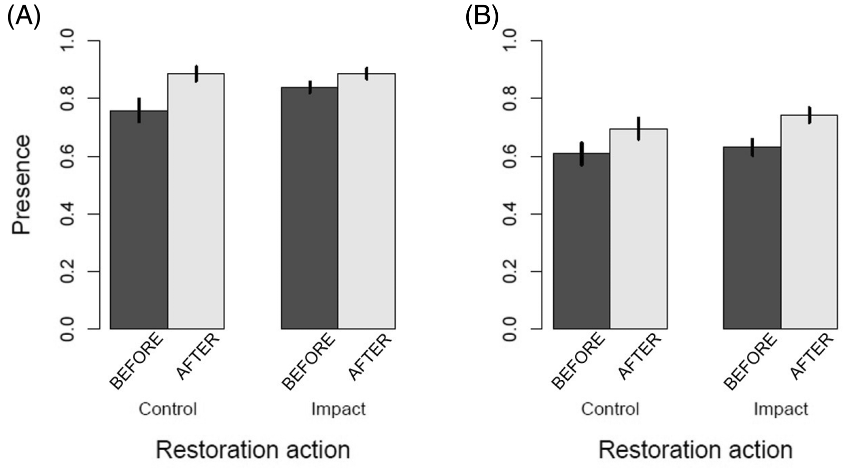

Figure 3. The mean presence, expressed as the proportion of recording nights with one or more recordings, plotted for (A) *Myotis* spp. and (B) *Eptesicus nilssonii* in both control and impacted sites before (in black) and after (in gray) the restoration action. Within the context of the BACI design of this study, "Impact" sites are located in wetlands that were restored, whereas no restoration action was undertaken in "Control" sites. Error bars represent ± SE. See Table S2 for the number of sites. Plotted here are the raw data.

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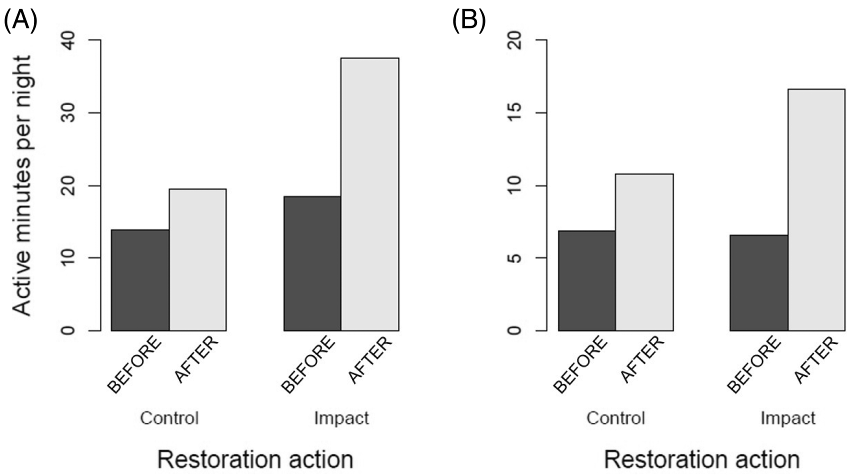

Figure 4. The mean active minutes per night plotted for (A) *Myotis* spp. and (B) *Eptesicus nilssonii* in both control and impacted sites before (in black) and after (in gray) the restoration action. Within the context of the BACI design of this study, "Impact" sites are located in wetlands that were restored, whereas no restoration action was undertaken in "Control" sites. See Table S2 for the number of sites. Plotted here are the raw data.

Discussion

Degradation of wetlands has been pronounced worldwide. Restoration actions are needed to restore their important ecosystem functions, functions that would benefit both humans and wildlife (Xu et al. 2019). We show using a BACI design that wetland restoration positively impacts the activity of *E. nilssonii* and *Myotis* spp. in the boreal zone of Finland. Our results are consistent with previous studies on restored wetlands (Menzel et al. 2005; Allagas 2020).

We do not find evidence that wetland restoration alters the presence of *E. nilssonii* or *Myotis* spp. as a group. A possible explanation regarding the observed absence of change in the bats' presence is the location of our sites in protected areas dominated by woodlands. In our study, the landscape surrounding the restored wetlands was forested and bat presence was high prior to restoration. Most likely, the landscape already provided plenty of roosting sites explaining why the wetland restoration did not markedly alter the presence of bats. Moreover, our monitoring areas being protected could be interpreted as a sign of good-quality habitats for the monitored species, already prior to restoration as suggested by the overall high presence. Consequently, restoring wetlands in poor-quality or less wooded landscapes could lead to different results in terms of bat presence and activity, but this assertion needs to be tested. For instance, trees that are left in restored wetlands may die and decay slowly due to the permanent water. Such trees may improve roosting opportunities, especially for bat species that roost under bark or in tree crevices, such as *Myotis brandtii* (Dietz et al. 2009; Tillon & Aulagnier 2014). The opportunities for roosting are especially important if surrounding habitats are not suitable for roosting (due to e.g., an absence of old trees or buildings). As we studied *Myotis* species as a group only, the individual presence of the four *Myotis* species at our sites is unknown, as well as the consequence of restoration on their presence. As *Myotis* species show differences in foraging or roosting habitat preferences (Swift 1997; Parsons & Jones 2003), we hypothesize that the changes at the restored sites (water level rise, tree felling) could be strong enough to attract certain *Myotis* species (the trawling *M. daubentonii*) as well as repel others (the forest *M. nattereri*). These changes would not show when looking at *Myotis* bats as a group, one species' increase possibly balancing out the decrease of another one. Identification of all *Myotis* calls to the species level would be necessary to determine the presence and activity variations of *Myotis* species at our sites and the effects of restoration on them.

We found that activity levels of *E. nilssonii* and *Myotis* spp. both increased significantly at restored wetlands when compared to control sites. These results suggest that the higher activity of bats at our restored wetlands reflects their improved utilization as foraging grounds for several species. We interpret the increase in active minutes that we observed as indicative of bats being more likely to have nightly foraging territories at restored wetlands compared to control wetlands (Allagas 2020). However, more direct confirmation of this interpretation would require measuring the quantity of feeding buzzes at control and restored sites, before and after restoration. Wetland restoration includes typically the plugging of drainage ditches to facilitate water stagnation and achieve a general rise of the water level. The permanent presence of water favors the abundance of many insect species, with many among them found in the diet of Finnish bats (Vesterinen et al. 2016, 2018). For instance, the trawling bat *Myotis daubentonii* concentrates on Chironomidae, very common in the boreal region, while *E. nilssonii* is a Nematocera specialist (Vesterinen et al. 2016, 2018). Both these insect groups require aquatic environments for their development (Rydell 1986; Vesterinen et al. 2016, 2018). Therefore, aforementioned bat species, among others, will find abundant prey that fit their diet and foraging techniques in wetlands (Rydell 1986). It can take some time for aquatic vegetation to grow after restoration earthworks have been completed, and as a result, there is less available cover for insect prey to avoid predation by bats (Beranek et al. 2021). The permanent presence of water will also

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attract all bat species for their drinking needs, whether they are using the wetlands as foraging sites or not (Russo et al. 2016).

A second action conducted for restoration at many of the sites we studied was the felling of trees. Felling trees leads to opening up of habitat, which favors edge-space species such as *E. nilssonii*, but can repel forest species, for example, *Myotis nattereri*, if the habitats are too open (Swift 1997; Parsons & Jones 2003). This could also explain why activity of bats increased after restoration (Menzel et al. 2005). We did not here analyze how site-specific restoration affects the bat fauna, but it is likely that details of how the restoration is carried out has consequences for species composition. There are no clear numbers on the suitable proportions of open and close habitats for different bat species, but in general one can argue that a more homogeneous landscape will lead to impoverishment of the bat community (Hayes & Loeb 2007). From that perspective, restoration of wetlands creates important heterogeneity at the landscape level, especially in terms of foraging opportunities. Thus, we believe that the restoration of wetlands can improve quality of surrounding habitats as well, for bats but also other taxa such as insects. We would expect bat activity, as well as foraging activity, to increase in habitats surrounding restored wetlands (Allagas 2020).

Furthermore, all our sites were located in Southern Finland, and our findings may not generalize to parts of the boreal zone in higher latitudes. In particular, bat abundance and species diversity in higher latitudes is low (Charbonnier et al. 2016), while wetlands are numerous, and under such conditions a restored wetland could just be one more wetland among many others, and could not appear as attractive as one in Southern Finland.

Our study considered the effect of wetland restoration on bats during approximately 2 years. It will be important to follow the long-term effect of wetland restorations on bats. This is because the presence of aquatic vegetation is expected to increase and may alter the attractivity of the wetland to bats. For example, trawling bats, such as *M. daubentonii*, are attracted to wetlands by the abundance and availability of insects. If the surface of water is covered by vegetation (reeds for instance), it would offer cover for insects and therefore decrease the foraging success of bats (Beranek et al. 2021). Apart from the dynamics of vegetation, water bodies should also be monitored for eutrophication at current and future restored wetlands, as it is positively associated with the increase of aquatic vegetation biomass (Partanen 2007).

Our results show an increased activity of *E. nilssonii* and *Myotis* spp. at restored wetlands, indicating that these sites play a significant role for bat foraging, drinking, and potentially roosting, similarly to natural wetlands (Allagas 2020). These results are also the first to investigate the effects of restoration of wetlands on bats in Europe and in the boreal climate. It demonstrates the usefulness of restoring wetlands for bat conservation, among other taxa, and the immediacy of the results.

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Supporting Information

The following information may be found in the online version of this article:

Table S1. Description of the study sites.
Table S2. The number of sites with bat recordings categorized as before or after for both control sites and sites impacted by the restoration action.
Table S3. Recording of species other *E. nilssonii* and *Myotis* spp. at our sites during the 4 years of monitoring.
Table S4. Results of a generalized linear mixed model (*Myotis* spp.).
Table S5. Results of a generalized linear mixed model (*E. nilssonii*).
Table S6. Results of a generalized linear mixed model with negative binomial errors and logarithmic link on the number of monthly active minutes for *Myotis* spp.
Table S7. Results of a generalized linear mixed model with negative binomial errors and logarithmic link on the number of monthly active minutes for *E. nilssonii*.

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