Thresholds of Habitat Disturbance and Food Availability for the Eastern Whip-poor-will

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Abstract

This study investigated disturbance tolerance thresholds for moth abundance across The Land Between ecotonal landscape in Ontario, Canada, with the goal of informing conservation measures for the Eastern Whip-poor-will (Antrostomus vociferus). Using Robinson light traps across 146 sites representing residential, agricultural, forestry, hydro corridor, and aggregate pit land-use treatments, we identified consistent declines in moth abundance when natural cover dropped below approximately 65–70%. Habitat heterogeneity (patchiness) buffered these declines, and subdivisions and shoreline developments produced the lowest biomass overall. The findings highlight the need to preserve high levels of natural cover and landscape patchiness to sustain moth populations and provide prey availability for aerial insectivores. Conservation implications and research needs are discussed.

Introduction

The Eastern Whip-poor-will (EWPW) is a nocturnal aerial insectivore whose populations have declined significantly in recent decades. Its dependence on moths as prey makes it particularly sensitive to landscape changes that alter moth abundance. Previous research has linked insect declines to urbanization, agriculture, forestry, and other land-use disturbances. However, the thresholds at which natural cover loss results in significant declines in moth biomass have not been well quantified. This study addresses this gap by identifying tipping points in natural cover and habitat heterogeneity, providing evidence-based recommendations for conservation and land-use planning. (COSEWIC, 2009; Environment and Climate Change Canada, 2023; Ontario MECP, 2019). (Sánchez-Bayo and Wyckhuys, 2019; Wagner, 2021; Tscharntke et al., 2012; Fahrig, 2017)

Methods

Robinson light traps were deployed at 146 sampling sites across The Land Between region. Sites were stratified by land-use type, including residential, agricultural, forestry plantations, hydro corridors, and aggregate pits. Sampling was conducted across multiple scales, with landscape metrics calculated for radii ranging from 0.5 km to 10 km around each site. Analyses evaluated relationships between moth abundance and percentage natural cover, as well as the role of habitat patchiness (heterogeneity). Statistical models assessed thresholds at which moth abundance declined sharply in relation to natural cover, with particular attention to the 60–70% threshold range. Full methodological detail, including trap design, site classification, and statistical procedures, is provided in the original draft and retained here in order to ensure reproducibility and transparency. (Jones et al., 2016)

Results

Moth abundance consistently declined when natural cover dropped below 65–70% in residential landscapes. This threshold was evident across scales of analysis. Patchiness in the landscape buffered declines, supporting higher moth abundance under equivalent levels of disturbance when habitats were more heterogeneous. Subdivisions and shoreline developments exhibited the lowest moth biomass, while agriculture yielded the lowest mean abundance but with high variability. Forestry plantations and hydro corridors reduced moth abundance, though aggregate pits produced more localized effects. (Tscharntke et al., 2012; Fahrig, 2017)

Discussion

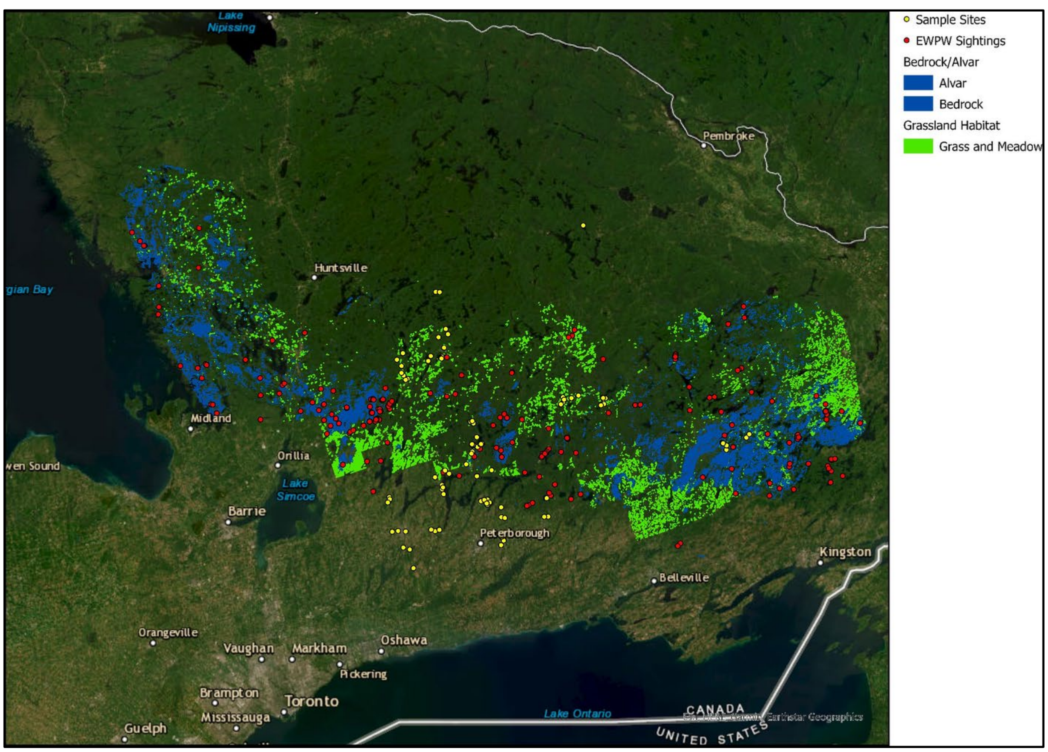

Figure 1. Sample areas relative to known occurrences of eastern whippoorwill in The Land Between

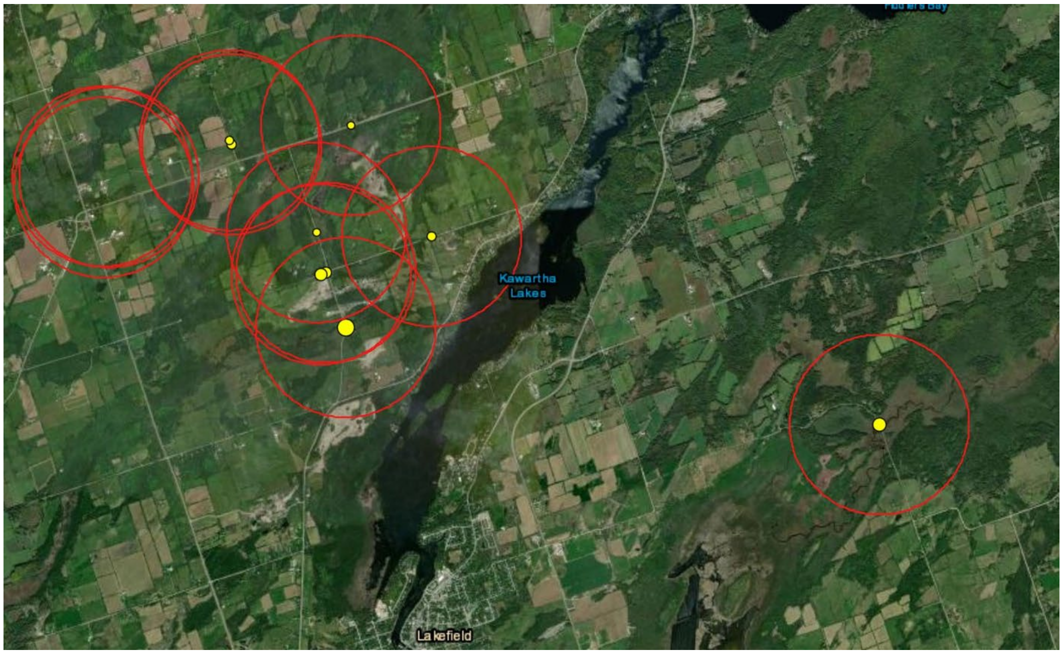

Figure 2. Example of samples across diversity of conditions. (Circle sizes depict relative weights of samples).

Natural cover vs lepidoptera weight (Lakes Removed)

0.5km	**2km**	**10km**
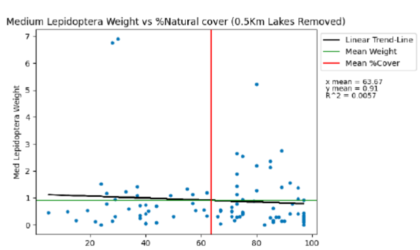	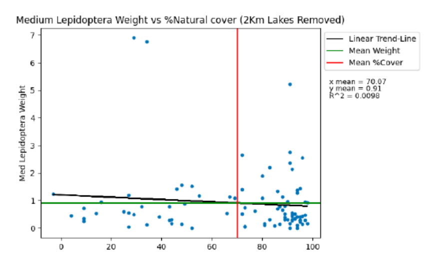	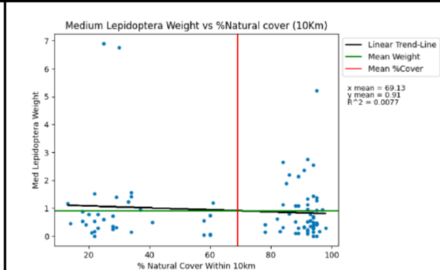
Figure 2.1 **Hypothesis Sample Ids: ['1-11', '16-3', '17-C-1', '25-4', '4-13', '5-16', '5-3', '5-6', '6-10', '8-10', '8-11', '8-12']** **Null Sample Ids: ['1-5', '1-9', '14-1', '14-3', '15-3', '15-4', '16-1', '16-2', '17-2-1', '17-2-2', '17-C-2', '2-13', '2-9', '24-1', '24-3', '25-3', '26-1', '26-2', '26-3', '3-9', '4-12', '4-8', '5-1', '5-8', '6-1', '6-2', '6-5', '6-7', '8-1', '8-2', '8-4', '8-5', '8-7', '8-9']**	*Figure 2.2* **Hypothesis Sample Ids: ['1-11', '16-3', '25-4', '4-13', '5-16', '5-3', '5-6', '6-10', '8-10', '8-11', '8-12']** **Null Sample Ids: ['1-12', '1-5', '14-1', '14-2', '14-3', '15-1', '15-2', '15-3', '15-4', '16-1', '16-2', '2-13', '2-9', '24-1', '24-2', '24-3', '25-2', '25-3', '26-1', '26-2', '26-3', '26-4', '3-9', '4-12', '4-8', '5-1', '5-10', '5-8', '6-1', '6-2', '6-5', '6-7', '7-6', '7-7', '7-8', '8-1', '8-2', '8-4', '8-5']**	*Figure 2.3* **Hypothesis Sample Ids: ['16-3', '25-4', '4-13', '5-16', '5-3', '5-6', '6-10', '8-10', '8-11', '8-12']** **Null Sample Ids: ['1-12', '1-5', '14-1', '14-2', '14-3', '15-1', '15-2', '15-3', '15-4', '16-1', '16-2', '2-13', '2-9', '24-1', '24-2', '24-3', '25-2', '25-3', '26-1', '26-2', '26-3', '26-4', '3-9', '4-12', '4-8', '5-1', '5-10', '5-8', '6-1', '6-2', '6-5', '6-7', '8-1', '8-2', '8-4', '8-5']**

Figure 3. Regression of weights versus natural cover measured within increasing radii (removing lake areas as part of the estimated cover).

Residential landscapes

Analyses of residential landscapes revealed strong threshold effects, with moth abundance declining steeply once natural cover fell below approximately 65–70%. Subdivisions consistently produced the lowest biomass, linked to hardened surfaces, limited natural corridors, and reduced vegetative cover. By contrast, rural residential areas with larger lots and retained natural elements supported higher abundance, demonstrating the buffering role of residual habitat. Shoreline developments further suppressed moth abundance, likely due to lake-edge barriers, altered microclimates, and intensified recreational disturbance. Anomalies included occasional sites where moth abundance was higher than expected despite moderate natural cover loss; these were often associated with nearby wetlands or unusually intact corridors. It should be noted that analyses were separated to represent ideal conditions, isolating residential influences without compounding effects from agriculture or forestry.

Agricultural systems

Agricultural areas produced the lowest mean moth abundance overall but displayed considerable variability depending on practice. Cropping systems were consistently associated with reduced abundance, linked to pesticide and fertilizer use and the absence of host plants. Pasturing produced more variable outcomes; sites retaining hedgerows or treed windrows supported higher abundance compared to intensively grazed lands. Old fields, by contrast, supported unexpectedly high moth abundance, functioning as reservoirs of host plant diversity. Anomalies in agricultural contexts often reflected differences in disclosure of management practices, underlining the need for greater transparency in land-use data. These results emphasize the need for conservation measures that retain semi-natural elements such as hedgerows, and for research separating intensive from low-intensity pasturing effects. (García de León et al., 2021; Kratschmer et al., 2024)

Forestry

Forestry treatments showed that plantations generally reduced moth abundance compared to natural forests. Uniform structure and low understory diversity limited host plant availability. Natural mixed forests consistently supported higher abundance, highlighting the value of structural complexity and patchiness. These findings suggest that forestry practices maintaining mixed stands, intact understories, and edge habitats will help sustain moth biomass. Research needs include long-term monitoring of selective harvest regimes and their effects on prey availability for insectivores.

Hydro corridors

Hydro corridors were typically associated with reduced moth abundance, attributable to vegetation clearing and possible herbicide use. Sites where corridors intersected wetlands displayed partial resilience, suggesting that wetland vegetation and microclimates can buffer against corridor impacts. Further research is needed to assess the role of herbicide regimes, particularly glyphosate, in shaping insect prey availability within these corridors.

Aggregate pits

Aggregate pits exerted primarily localized impacts, with dust, noise, and direct habitat loss suppressing moth abundance in immediate proximity. Beyond their footprint, effects were limited compared to other land uses. Restoration of pits with native vegetation represents a viable strategy for reintroducing host plants and buffering against biodiversity loss.

Other situations and environmental vectors

Environmental conditions also mediated moth abundance. Night lighting produced strong negative effects, interfering with moth navigation and trap visibility. Rainfall events suppressed flight activity, producing marked declines in abundance. Wind reduced activity at higher speeds, though thresholds require further study. Noise effects were relatively minor compared to lighting and rainfall. These results reinforce the importance of considering environmental vectors alongside land-use patterns when evaluating prey availability. Overall, there were strong negative adjacencies recorded with subdivisions and night lighting which show the most consistent negative associations; golf courses also track low weights. (Owens et al., 2020; Degen et al., 2024)

0.5km

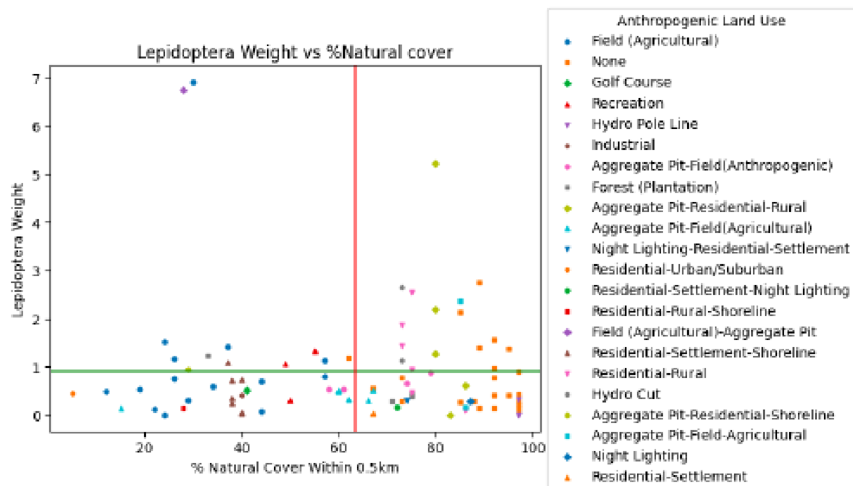

Figure 3.1

Hypothesis Sample Ids: ['1-11', '16-3', '17-C-1', '25-4', '4-13', '5-16', '5-3', '5-6', '6-10', '8-10', '8-11', '8-12']

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Figure 4. Sample weight versus natural cover categorized according to dominant cover types within a radius of 0.5km.

2km

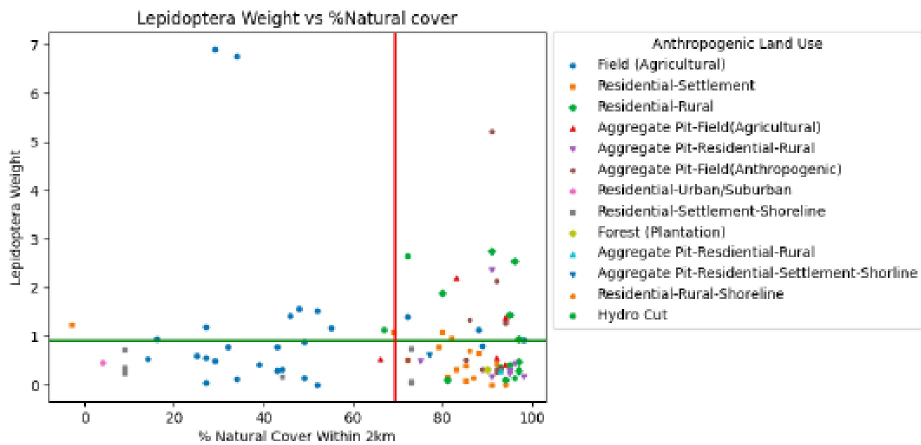

Figure 3.2

Hypothesis Sample Ids: ['1-11', '16-3', '25-4', '4-13', '5-16', '5-3', '5-6', '6-10', '8-10', '8-11', '8-12']
Null Sample Ids: ['1-12', '1-5', '14-1', '14-2', '14-3', '15-1', '15-2', '15-3', '15-4', '16-1', '16-2', '2-13', '2-9', '24-1', '24-2', '24-3', '25-2', '25-3', '26-1', '26-2', '26-3', '26-4', '3-9', '4-12', '4-8', '5-1', '5-10', '5-8', '6-1', '6-2', '6-5', '6-7', '7-6', '7-7', '7-8', '8-1', '8-2', '8-4', '8-5']

Figure 5. Sample weight versus natural cover categorized according to dominant cover types within a radius of 2km.

Synthesis and Implications

Together, these findings confirm that moth abundance, and consequently prey availability for Eastern Whip-poor-will, is governed by thresholds in natural cover and influenced by multiple land-use practices. Maintaining landscapes with ≥70% natural cover is critical, but so too is preserving patchiness, ecotones, and corridors that buffer against declines. Subdivisions and shoreline developments present the most severe risks, while agricultural and forestry practices vary in their impacts depending on management. Hydro corridors and aggregate pits can be managed to reduce negative effects, particularly through reduced herbicide use and habitat restoration. Future research should focus on refining thresholds under agricultural and forestry regimes, clarifying the role of microclimate effects at shorelines, and expanding long-term, multi-year monitoring to strengthen inference. (Tscharntke et al., 2012; Fahrig, 2017)

Table 1. Summary of recommended best management practices (BMPs) based on threshold analyses

Context	Best Management Practices
Residential	Maintain ≥70% natural cover; design subdivisions with native vegetation, mast trees, and corridors; restore shorelines.
Agriculture	Retain hedgerows and windrows; reduce pesticide use; maintain patches of natural vegetation.
Forestry	Favor mixed natural forests; avoid monoculture plantations; retain understory and patchiness.
Hydro corridors	Limit herbicide use; retain wetlands to buffer impacts.
Aggregate pits	Limit footprint; rehabilitate pits with native vegetation post-use.

Next Research Steps to Refine Best Management Practices

1) Confirm thresholds and reduce uncertainty

Future work should focus on repeating core sites across multiple years to strengthen evidence for natural-cover thresholds and patchiness benefits. Models should be refined to account for weather and moonlight effects, and re-sampling should target sites that produced unexpectedly low results despite high natural cover, to ensure protocols are robust.

2) Finer-grain focus on land uses

Residential categories should be separated (exurban, subdivisions, urban) to identify which design features, such as retaining mast trees, native corridors, or managing light, buffer impacts. Agricultural sites should be divided into cropping, pasture, hobby, and fallow fields, with simple land-use records collected to link outcomes to practices. In forestry, comparisons between plantations and mixed or open-canopy stands are needed to identify management strategies that sustain prey.

3) Treat adjacency as a measurable pressure

Research should quantify how far negative influences from subdivisions, hydro corridors, and golf courses extend into nearby habitat, and test specific mitigations like reduced herbicide use, light shielding, or native buffers. Lighting in particular should be studied in terms of intensity, spectrum, and timing to set clear "dark sky" BMP standards.

4) From biomass to biodiversity

Work should go beyond measuring moth weight to assessing species diversity, since different taxa vary in tolerance and ecological role. Community-science protocols, such as white-sheet moth nights, could be introduced to increase sampling coverage while engaging the public.

5) Fill knowledge gaps and ground-truth anomalies

Direct sampling in rock barrens, old fields, and industrial or urban edge areas will help clarify their roles in patchiness and resilience. Lakes should be treated as barriers, and further work should measure how shoreline microclimates reduce productivity. Comparing regions with and without defoliation outbreaks will also show how episodic events shift prey availability.

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