Hide and sneak: mapping distributions of elusive mustelids in Ohio

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Introduction

Weasels are a key part of mammal communities in North America but have been understudied in research. Systematic survey efforts are lacking due to challenges in detecting (1) and identifying (2) weasels. With recent reports of population declines and possible range shifts across North America (3,4), we seek to understand the current status of these species in Ohio.

We modeled suitability for three weasel species (Fig. 1) across Ohio:

1. Long-tailed weasel (*Neogale frenata*)
2. Short-tailed weasel (*Mustela richardsonii*)
3. Least weasel (*Mustela nivalis*)

Objectives:

- Describe current-day suitability and potential ranges of three weasel species in Ohio.
- Develop integrated species distribution models (iSDMs) to understand possible weasel distributions in Ohio to inform future management and research.

Methods

1. Collected all available occurrence records between 1981 and 2025 (Fig. 2).
   - **Presence-only data:** iNaturalist, GBIF, sightings reported to the Ohio Division of Wildlife.
   - **Presence-absence data:** Camera trap and AHDriFT data from Wildlife Insights, Ohio University, and Cleveland Metroparks.
2. Created iSDMs using integrated nested Laplace approximation (INLA) via the *intSDM* package (5) in R with various combinations of covariates (6).
   - Uninformative prior distribution set for each model.
   - Triangulation mesh generated for spatial correlation calculations.
   - **Environmental Covariates:** average annual temperature, precipitation, elevation, aspect (eastness and northness).
   - **Land Cover Covariates:** proportion of forest, grassland, cropland, urban, water.
3. Used stepwise backward selection from the full models with Watanabe–Akaike information criterion (WAIC) to converge on a final model for each species.

Figure 1. The three weasel species of Ohio as seen on iNaturalist. Image credit: @smays, @carterdorscht, @a_ma_bird.

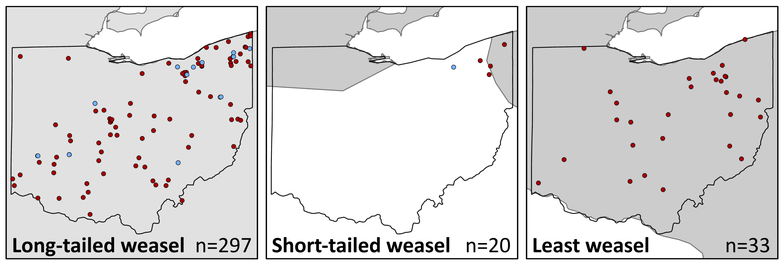

Figure 2. Compiled weasel occurrences in Ohio. IUCN species' ranges are shaded in gray. Red points indicate presence-only occurrences and blue points indicate presence-absence occurrences.

Results

We collected 130 presence-only occurrences and 220 presence-absence occurrences (Fig. 2). Camera trap and AHDriFT sampling covered 170,670 camera-nights. Best models were selected using WAIC (Table 1).

The predicted suitability for long-tailed and least weasels showed a similar pattern with both species having higher suitability in the northeast (Fig. 3). Short-tailed weasels had the most continuous distribution, with higher suitability along the southern half of the state and the northeast (Fig. 3)

Long-tailed weasels suitability showed positive relationships with all land cover covariates, and weaker negative relationships with temperature and eastness (Fig. 4). Short-tailed weasels had strong negative relationship with water. Least weasels showed a negative effect for precipitation and cropland (Fig. 4).

Table 1. Statistics for final models for each species. ΔWAIC reported as the difference between the final model and equivalent full model. P_D is the effective number of parameters reported for WAIC.

Species	# Spatial Covariates	WAIC	ΔWAIC	P_D (WAIC)	Marginal log likelihood
Long-tailed	9	2322.62	6.77	6.61	-1319.98
Short-tailed	6	239.39	637.76	23.82	-135.86
Least	5	109.78	199.05	1.19	-130.20

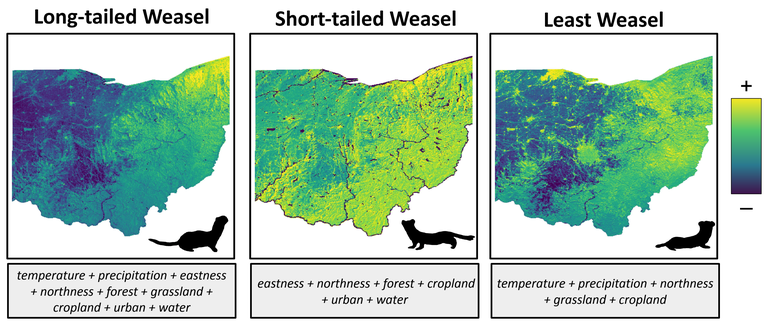

Figure 3. iSDM suitability maps. Color scale represents mean predicted suitability and the covariates included in the final model are given below each map.

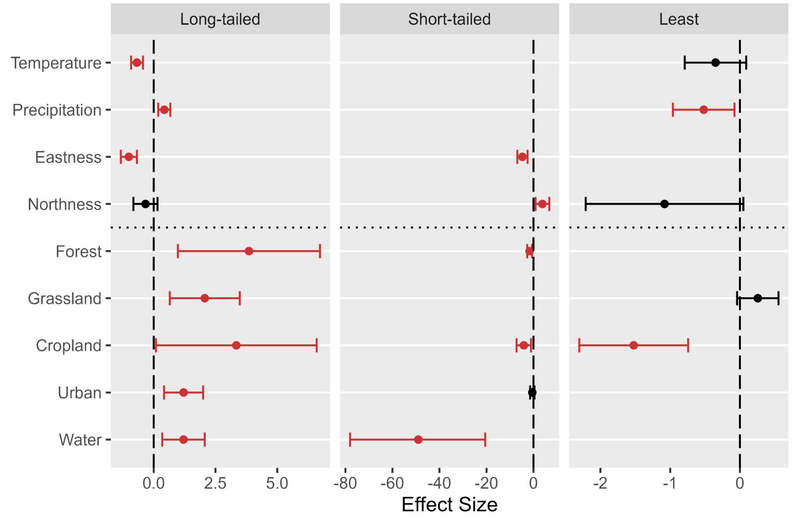

Figure 4. Effect sizes of the covariates included in the final model for each species. Error bars represent credible intervals. Significant covariates are indicated in red.

Discussion

Weasels within Ohio favor the eastern and southern portions of the state, generally within the western Allegheny plateau and Erie drift plain ecoregions. Long-tailed and least weasel suitability show a high degree of similarity, consistent with the those seen in previous suitability estimates for these two species (3).

The model for short-tailed weasels is clearly overfit (extreme negative effect with water and high P_D) due to few observations that are clustered in a small region. More accurate results would likely be produced if the model and mesh were restricted to the species' known range in the northeastern Ohio (7). As a next step, we will explore additional covariates (e.g., snow cover) that may improve the model and help explain the unusually concentrated presence of the species.

Future monitoring should prioritize areas with high predicted suitability that remain unsampled, as well as areas that have been historically overlooked (e.g. northwestern Ohio). Targeting both will improve statewide coverage, increase the likelihood of detecting weasels, and facilitate model validation.

References

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