Empirical modeling of vole habitat suitability in a restored tallgrass prairie

Chris Nootenboom, Cameron Meyer Shorb, and Emma Velis
Environmental Studies Department, Carleton College, Northfield, MN

Introduction

Edge effects are commonly cited as a source of biodiversity loss in fragmented habitat, through factors including increased predation rates and predator avoidance (Lidicker 1999; Pusenius and Schmidt 2002).

Previous study of voles in the Arb

- Recorded voles (Microtus spp.) with baited camera traps at 70 points in our study area, the tallgrass prairie of the Carleton College Cowling Arboretum (“the Arb”) (Freymiller et al. 2014).
- Found an unusual edge effect: voles favored middle distances (8 and 16 m) over close (0, 2, and 4 m) and far (32 and 64 m).

This edge effect is inconsistent with the hypothesized mechanism (human and dog avoidance), which would predict vole frequency to increase with distance. We set out to perform further spatial analysis to reveal whether other spatial variables are confounding or are responsible for the observed edge effect pattern.

Research questions

1. What is the importance of trail edge effects on vole frequency relative to other spatial habitat variables?
2. Given what we find about vole habitat preferences and the Arb landscape, what vole frequencies do we expect throughout the study area?

Methods

1. Determining the impact of spatial variables
   - Data collection and processing: See Table 1.
   - Multivariate regression
     - We used Exploratory Regression (ArcMap) to run all possible regression models. From the models with the highest $R^2$ value (0.14), we selected the model with the lowest AICc (90.49).
     - $R^2$ gives the percentage of variance accounted for by the model. A low AICc indicates the model explains the highest percentage of variability with the fewest variables.
     - We calculated variable coefficients using regression analysis ($R$).
2. Predicting relative habitat suitability
   - Input coefficients in Raster Calculator (ArcMap) to develop a predicted frequency surface.

Results

The predicted frequency map was created using a formula

$$\text{Vole Frequency} = -0.026681 \times (\text{Slope}) + 0.014624 \times (\text{Percent Grass Cover}) - 0.386852$$

The formula used to produce this map was

$$\text{Vole Frequency} = -0.026681 \times (\text{Slope}) + 0.014624 \times (\text{Percent Grass Cover}) - 0.386852$$

Table 1. Initial inputs to the habitat model.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Methods and notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from trail</td>
<td>Euclidean distance from nearest walking trail.</td>
</tr>
<tr>
<td>Species richness</td>
<td>Interpreted from 143 sample points.</td>
</tr>
<tr>
<td>% C3 grass</td>
<td>Inverse distance-weighted $r=2$ (standard) $n=4$.</td>
</tr>
<tr>
<td>% C4 grass</td>
<td>Strong local influence reflects patchy vegetation.</td>
</tr>
<tr>
<td>% Total grass</td>
<td>4 points reflects grid pattern of sample points.</td>
</tr>
<tr>
<td>% Legumes</td>
<td>Interpolation constrained to planting year.</td>
</tr>
<tr>
<td>% Forbs</td>
<td></td>
</tr>
<tr>
<td>Planting year</td>
<td>The year the prairie (formerly in agriculture) was seeded with native plants.</td>
</tr>
<tr>
<td>Summers since last burn</td>
<td>Deeper litter could facilitate predator avoidance and nest building.</td>
</tr>
<tr>
<td>Elevation</td>
<td>Calculated from elevation.</td>
</tr>
<tr>
<td>Slope</td>
<td>Calculated from slope.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Calculated from slope.</td>
</tr>
</tbody>
</table>

Discussion

- The predicted frequency map was created using a formula derived from frequency of vole visits to baited traps per hour. While it isn’t possible to predict actual vole frequency values using these data, we have used the map to predict relative probability of vole presence.
- When we took into account additional variables, distance from trail was not significant in any resulting model.
- Our best model incorporated only percent grass cover ($P=0.000689$) and slope ($P=0.116053$). However, this model only explains 14% of variation in vole frequency.
- The regression performed was only capable of predicting the linear impact of independent variables on vole presence. It is possible that there is an edge effect trend which follows a non-linear formula, but we have no empirical data to suggest what that formula might be.

References


Acknowledgments

We thank the Carleton GIS Lab for providing Arboretum data, the Hernández Lab (Biology Department, Carleton College) for vole observation data; Mark Mckone (Biology Department, Carleton College) for prairie plant community data; and Nancy Broker (Cowling Arboretum, Carleton College) for burn history data. We are grateful to Laura Freymiller for field assistance and Tom Grodzicki for his help with statistical analysis.