A MULTI-SCALE ASSESSMENT OF BEETLE DIVERSITY AND LANDSCAPE PROPERTIES

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1. INTRODUCTION

The issue of scale is important in ecology. Many studies have indicated that ecological patterns can vary with the grain and extent of the study, and thus it is difficult to extrapolate from fine to coarse scales. Furthermore, habitats are generally not homogenous, so interactions between an organism and its environment, as well as the scale at which they are examined, are primary factors underlying the patterns or processes being studied.

This study has many facets, but we are particularly interested in how spatial patterns of beetle species richness and environmental variables change with scale. Other questions address whether there are spatial scales where correlations between beetle abundance and environmental measures peak? Identifying such scales should provide insights to the processes responsible for the observed patterns.

Eleodes spp.

2. FIELD METHODS

The study was conducted on the short-grass steppe of the 62,800 km^2 Central Plains Experimental Range (CPER), 60 km northeast of Fort Collins, Colorado. Using coarse-scale maps of primary vegetation and soil texture, we selected four 2-km transects (labeled A, B, C, D) that encompass a gradient from upland to lowland floodplain habitat types. Transects were approximately parallel and separated by ca. 200 m (Figure 1).

Beetles were trapped every 20 m along each transect, during 18-23 June and 17-22 August 1998. Vegetation surveys were conducted by determining the percent coverage of bare ground, grass, forb, shrub, and cactus, as well as the number of shrubs (including *Atriplex* shrubs) within a 2-m radius of each trap (Figure 2).

3. DATA ANALYSIS

In order to understand how spatial patterns of beetle species richness and environmental variables change with scale, we used an analysis termed "two-term local variances", or TTLV (also commonly referred to as a "moving window" analysis). In the TTLV technique, a "window" of a particular block size is advanced along each transect one unit at a time, and adjacent blocks are analyzed. This technique is therefore insensitive to starting position along the transect.

To examine the spatial scales at which beetle abundance and environmental measures correlate with each other, we aggregated data by adding the total number of *Atriplex* shrubs and beetles using a technique similar to the "moving window" analysis. Data from two traps were added together, the "window" was advanced one trap along each transect, and the data were aggregated again. This process was continued with the size of the aggregation ranging from a single trap up to 80 traps. We performed regression analysis for environmental variables and beetle abundance to determine the scales of highest correlation.

Details of the TTLV or "moving window analysis" are as follows. Species richness of Tenebrionid beetles and shrub abundance were calculated for each trap and the average variance at 50 different block sizes was calculated using the following method: If the number of species in each trap is given by $x_1, x_2, \ldots, x_n$, it is possible to obtain a measure of variance at block size 1 as:

$$\text{average of } (\tfrac{1}{2}(x_1-x_2)^2, \tfrac{1}{2}(x_2-x_3)^2, \tfrac{1}{2}(x_3-x_4)^2, \text{etc})$$

variance at block size 2 is defined by:

$$\text{average of } (\tfrac{1}{4}(x_1+x_2-x_3-x_4)^2, \tfrac{1}{4}(x_2+x_3-x_4-x_5)^2, \text{etc})$$

and variance at block size 3 is defined as:

$$\text{average of all terms in the form of } (\tfrac{1}{6}(x_1+x_2+x_3-x_4-x_5-x_6)^2, \tfrac{1}{6}(x_2+x_3+x_4-x_5-x_6-x_7)^2, \text{etc.})$$

In effect, the results of the TTLV method indicate the patch dimensions of the variable being inspected. If patch distribution is random, or if patch size is less than 20 m, the graph line will remain constant. If patches are regularly distributed, however, there should be a peak in variance at the appropriate block size. Multiple peaks in the graph indicate multiple scales of pattern or nestedness of patches.

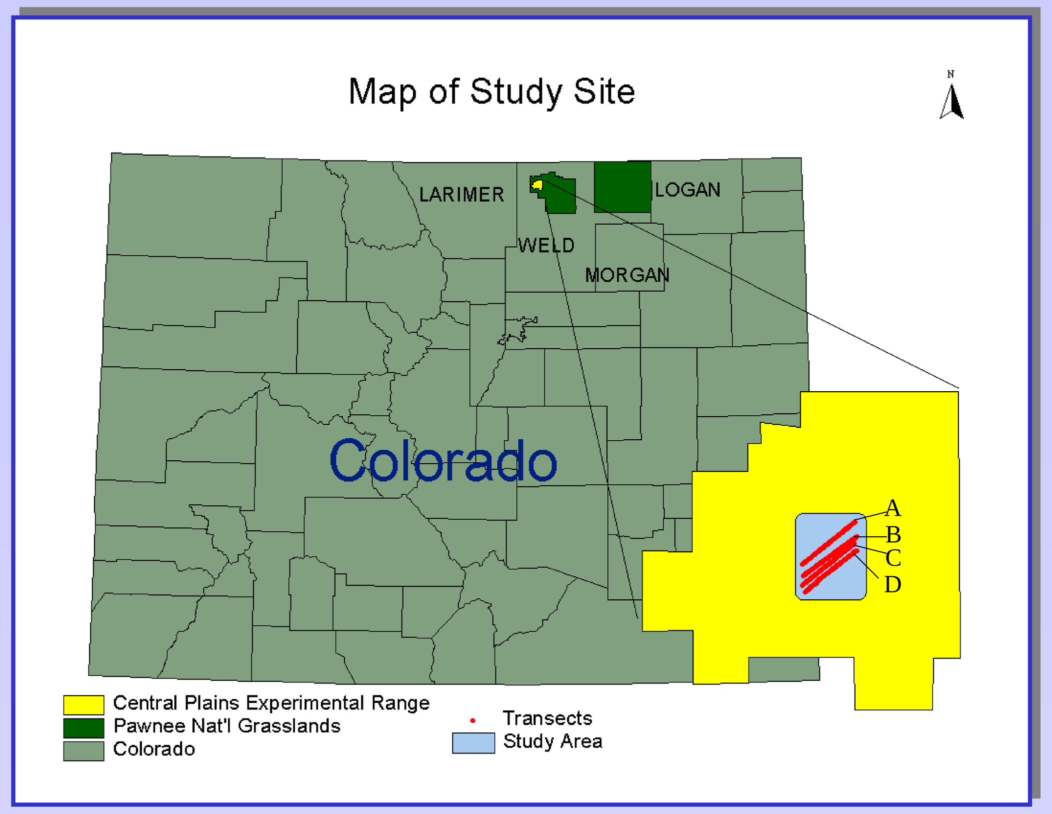

Figure 1: Study site and transect locations

Figure 2: A vegetation survey plot

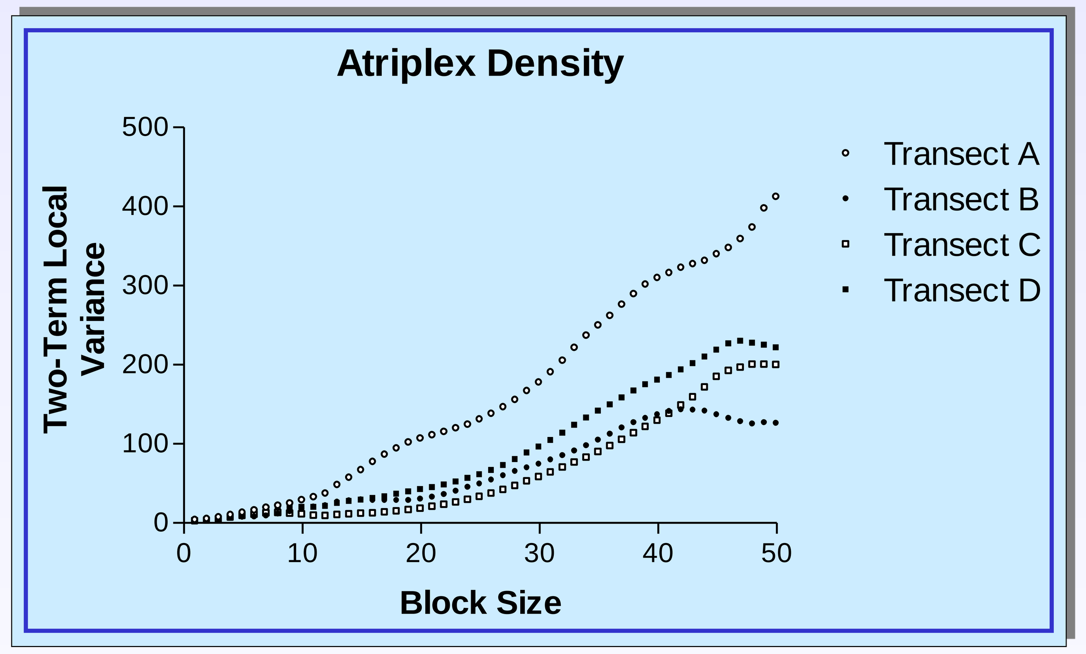

Figure 3. "Block Size" is defined as the number of traps within the moving window. Traps are 20 m apart

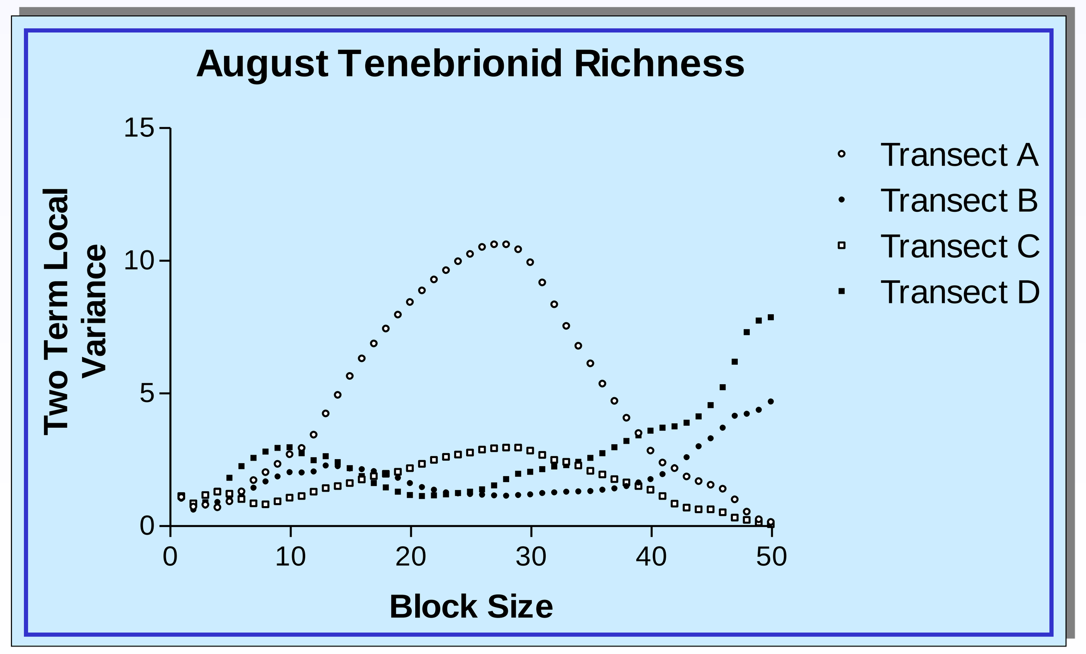

Figure 4

4. RESULTS

Overall, 11,552 individual beetles were captured and identified. This accumulation of beetles was composed of 173 species within 28 families, with 133 beetle species observed in the June sampling and 108 in August. The overall mean number of beetles per trap was 14.2 (SD=16), and the mean species richness per trap was 4.0 (SD=2.3). Although 28 families were represented in this sampling period, 5 families (Scarabaeidae, Tenebrionidae, Chrysomelidae, Curculionidae and Carabidae) represent nearly 95% of all beetles captured.

Patterns of *Atriplex* shrub density vary with scale (Fig. 3). Variance generally rises in all four transects as block size increases, indicating that *Atriplex* patch dimensions are defined at block sizes greater than 50 traps.

Tenebrionid beetle species richness also varies with scale, but in a different manner (Fig. 4). Patch sizes in transects A and C are indicated at scales of around 28 traps, while transects B and D indicate patch sizes at scales of 10 traps and again near 50.

The scales at which correlations between Tenebrionid beetle abundance and *Atriplex* shrub abundance as a function of distance are highest are indicated in Fig. 5. As with Figs. 3 and 4, the correlation between beetle and shrub abundance is variable among transects, although most transects exhibit distinct peaks.

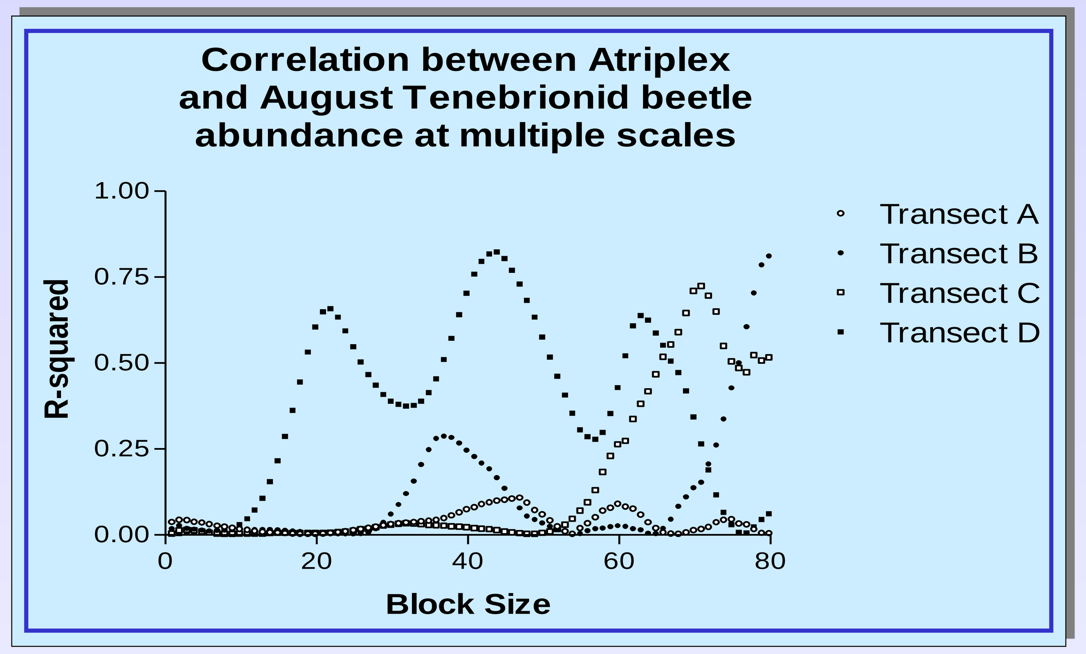

Figure 5

5. CONCLUSIONS

•The variance in beetles species richness and in environmental measures, as well as the correlation between beetle abundance and shrub abundance appears to be scale-dependent but highly variable among transects.

•Analyses conducted at a single spatial scale may fail to detect distributional patterns or correlations between organisms and their environment.

•Our study is providing insights into how the beetle community is coupled to the characteristics of the landscape, and the ways in which these relationships may change with associated changes in grain of the study.

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