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Brief communication

Incorporating spatial scale into ecological studies of *Rangifer*

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Spatial scale is integral to description in ecology, including the ecology of *Rangifer.* Increasingly, we are aware that observations in ecology may be fundamentally altered, or even reversed, as a result of seemingly trivial changes in scale (Wiens, 1989). Scale has been labelled by some as the unifying feature of ecology (Allen & Hoekstra, 1992).

Particularly important are changes in the bounds of the study area (i.e., the extent) or the size of individual sampling unit (i.e., the grain). As an example, consider species associations. Such pair-wise relationships, as between caribou and moose, are typically conducted by noting the presence or absence of species in a quadrat. The results may be scale-dependent: the choice of grain, in the form of quadrat size, can dictate the direction of species associations, i.e., whether positive or negative (e.g., Schaefer & Messier, 1994).

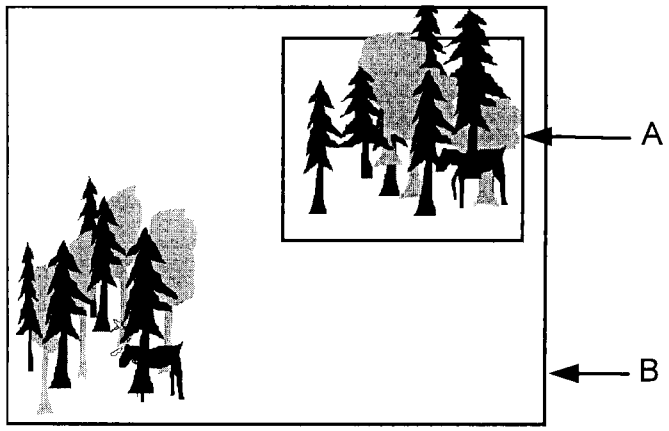

Fig. 1. Hypothetical habitat selection by an ungulate studied using small (A) and large (B) study areas.

Similarly, the choice of extent may strongly affect study conclusions. Suppose, for instance, that an animal selects strongly for a particular resource type, such as forest (Fig. 1). A study covering a large extent may indeed detect this pattern, whereas a study conducted using a smaller extent will likely conclude that no such pattern of selection exists (Fig. 1).

Unfortunately, current decisions regarding grain and extent in studies of caribou ecology are typically relegated to whim.

An organism-centred approach represents a rigorous methodology for incorporating scale. For example, in the study of caribou resource selection, a natural hierarchy of scales exists, from choice of home range to choice of plant species (e.g., Schaefer & Messier, 1995). An equally useful approach is to apply the techniques of spatial pattern analysis. Largely the domain of plant ecologists, these simple methods, such as paired-quadrat variance (Fig. 2), can indicate scales of pattern for further study (Ludwig & Reynolds, 1988).

Caribou carry out their ecological functions simultaneously on many scales. This implies that no one scale of study is universally appropriate. At the same time, larger scales may offer constraints,

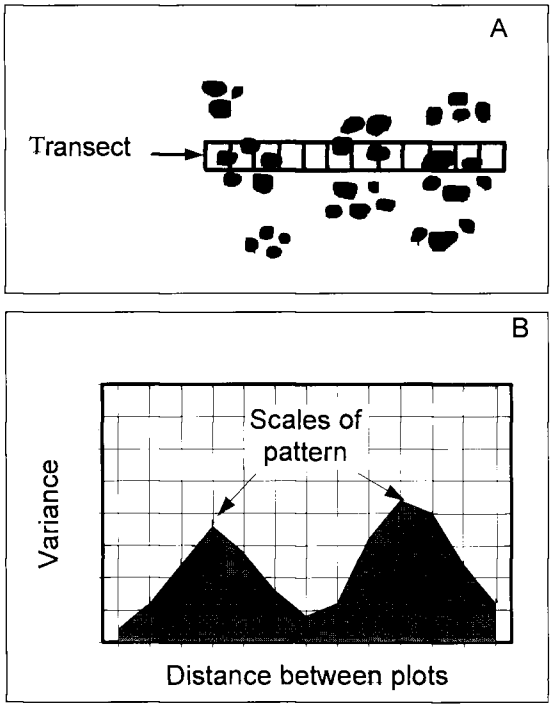

Fig. 2. Spatial pattern analysis of a hypothetical organism using paired-quadrat analysis (Ludwig & Reynolds, 1988). (A) Organism abundance is quantified using a set of contiguous quadrats. (B) Variance between pairs of quadrats is calculated and plotted as a function of inter-quadrat distance; peaks in the graph represent the scales of the clumped pattern.

and lower scales, explanations, for any scale of interest (Allen & Hoekstra, 1992). This suggests that a minimum of three scales is needed in research. For example, in the study of population dynamics, one might examine patterns on the levels of sub-population, population, and meta-population (Wells & Richmond, 1995). Fuller understanding of caribou ecology may come from descriptions that employ a hierarchy of spatial scales.

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