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Patch size, herbivore dispersal, and spatial scale: Landscape effects promoting herbivore outbreaks

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Patch Size, Herbivore Dispersal, and Spatial Scale: Landscape Effects Promoting Herbivore Outbreaks

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We examine the effect of patch size on the ability of herbivore populations to reach an outbreak density that results in host-plant defoliation. The intent of this study was to identify whether there were threshold amounts of habitat above which herbivores could outbreak and below which they would not. Theory suggests that when patches are the same size or larger than the typical dispersal distance of the herbivore, populations can build up more readily within those patches. In effect, herbivores would be dispersing within patches. Data were collected from 130 populations of forest tent caterpillar from 1993 through 1999 and the peak density reached at each of those sites was estimated. Around each sample point, the proportion forested vs unforested land was estimated from a classified photo-mosaic; no forest was recorded as zero, and complete forest cover as one. Forest cover estimates were taken from the mosaic at six spatial scales (53m, 106m, 212m, 425m, 850m and 1700m). The relationships between point estimates of tent caterpillar density and forest structure at each of the six spatial scales were examined to identify the [respective] patterns.

At all spatial scales, there were higher densities of tent caterpillar in areas where there was more forest. Among these six spatial scales however, only at the 850 m^2 scale was there evidence of a threshold amount of forest cover above which outbreaks occurred and below which they never occurred, thus producing a distinct 'step' in the relationship between cover and population size. With only one exception, all outbreak populations were in areas with more than 72% forest cover (measured at 850m by 850m), whereas no sites with less than 72% forest cover ever reached outbreak density.

The presence of a distinct threshold of forest cover for outbreaks, at the 850 m^2 scale, suggests that habitat patches of this size or greater equal or exceed the distance over which moths typically disperse and result in population build-up. This threshold is obscured at spatial scales of less than 850 m^2 because moths typically disperse beyond the scale at which structure is estimated; they are able to leave this area and still be within the larger single patches. At 1700 m^2 scale, the relationship also disappears because multiple patches are incorporated, increasing the variation of percentage forest cover relative to the occurrence of insect outbreaks. Although the 'typical' dispersal distance of forest tent caterpillar is not known, the scale of about 800 - 1000m seems reasonable.

Although this study was done on a non-weed feeding insect, the observed pattern suggests that there will be a specific threshold patch size of a weed that will facilitate the establishment and outbreak of each biocontrol agent. A similar approach could be used to

Proceedings of the X International Symposium on Biological Control of Weeds
4-14 July 1999, Montana State University, Bozeman, Montana, USA
Neal R. Spencer [ed.]. (2000)

indirectly estimate dispersal distances of established biocontrol control agents, such as *Aphthona* beetles on leafy spurge. Spread of the root beetles can be estimated by examining the relationship between spurge patch size and beetle population densities at multiple spatial scales. The spatial scale where a threshold response for an outbreak population occurs may provide an indirect estimate of beetle dispersal distances. Taking these patterns one step further, dispersal distance could dictate the optimal patch size into which releases are done in order to create an herbivore outbreak. As a rule of thumb, the pattern observed with forest tent caterpillar suggests that releases of biocontrol agents should be done in large patches of weeds where possible. Small patches, although not supporting outbreak populations, may still, however, serve as stepping stones for dispersal of the biocontrol agent once the insect has established and reached outbreak status.