Geographic patterns in population dynamics of the southern pine beetle

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Introduction

- Populations of southern pine beetle, *Dendroctonus frontalis* (Scolytidae) fluctuate from low endemic to high epidemic densities killing pines throughout the southeastern United States.
- Northern distribution limits of southern pine beetle are set by lethal winter temperatures (Ungerer et al. 1999).
- Southern pine beetles are aggregated within local infestations that are evident from aerial surveys. Infestations have demographic properties similar to univoltine insects. Old infestations die during winter and new infestations appear in early summer/late spring.
- Beetle abundance can be measured as: (1) number of individuals captured in pheromone traps; (2) volume of wood killed by beetles; and (3) number of infestations within a landscape.
- Analyses using volumes of wood killed have indicated that delayed density dependence is stronger in the south than in the north and that density independent effects (presumably from weather) play a larger role in the north than in the south (Ayres et al. unpublished).

Questions

- Do patterns of population dynamics depend on the scale at which abundance is measured?
- Are population dynamics similar in southern versus northern populations?
- Is there appreciable spatial synchrony in dynamics?

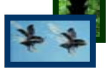
Material

Southern pine beetle captures from a standardized pheromone-based trapping program:

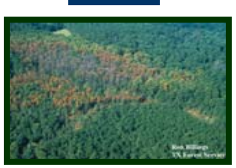
1987 - 2000

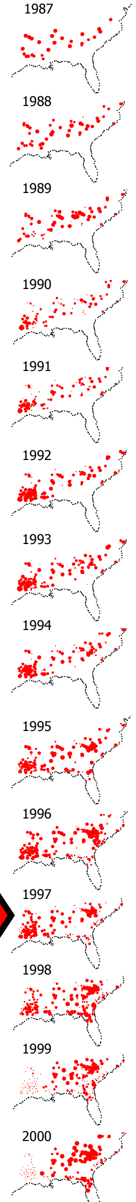
~70 sites (3 stands per site)

10 states with a range of climatic conditions.



Number of infestations from corresponding sites per 1000 host acres through 1987 - 2000.





Populations of beetles versus populations of infestations

TABLE 1. Patterns of significant negative density dependence in beetles vs. infestations, and southern vs. northern populations. *Y* = population growth rates = $\ln(N_t/N_{t-1})$. N_{t-1} and N_{t-2} indicate direct and delayed density dependence.

	N_{t-1}	N_{t-2}	R^2
Beetles			
Data pooled	X		0.16
Latitude <35°	X		0.15
Latitude >35°	X		0.19
Infestations			
Data pooled	X	X	0.26
Latitude <35°	X		0.22
Latitude >35°	X	X	0.49

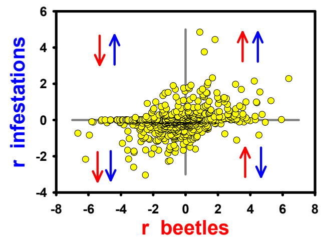
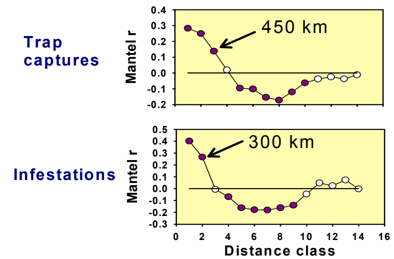


FIG 1. Population growth rates (r) correlated positively between populations of beetles and infestations. In some cases populations of infestation are increasing but beetles declining and vice versa.

Delayed negative density dependence, which is considered typical for cyclic southern pine beetle populations, was detected only in the infestation data (**TABLE 1**). And opposite to earlier results based on volumes of wood killed by beetles the populations of infestations showed delayed density dependence in the north but not in the south.

Spatial synchrony

Beetle population abundance covaries in space: 42-73% of the total variation in beetle abundance is among forests and only 9 – 27% of variation is among stands within a same forest.



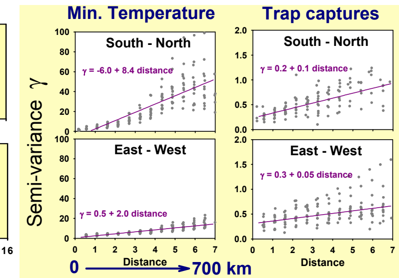


FIG 2. Correlograms indicating broad spatial synchrony in southern pine beetle populations, both in case of beetle captures (up to 450 km) and infestations per 1000 host acres (up to 300 km) throughout the southeastern United States during years 1987 – 1999. Closed circles show at which distance the spatial correlation is significantly higher or lower than the average correlation among sites throughout the southeastern U.S.

FIG 3. A test for winter temperatures as a cause of spatial synchrony in beetle abundance. Directional variograms show that minimum winter temperatures change more from north to south (upper left) than east to west (lower left). As predicted, beetle populations show a similar pattern of anisotropy: beetle abundance changes more north to south (upper right) than from east to west (lower right).

Conclusions

The same organism can display different population dynamics depending on the scale at which abundance is considered.

Populations of infestations may have emergent properties (i.e., not easily deduced from the attributes of beetles) that produce delayed density dependence and contribute to cyclical outbreaks at the landscape scale.

Beetle abundance is correlated at a spatial scale (>300 km) that is way beyond the dispersal distances of beetles or their predators (< 10 km). This indicates a role in landscape abundance patterns for some exogenous factor with high spatial autocorrelation (e.g., temperature or rainfall).

Spatio-temporal patterns in the occurrence of lethal winter air temperatures (<-16°C) may tend to synchronize abundance in space – and be an important exogenous force in temporal population dynamics.

Literature cited

Ungerer, M. T., M. P. Ayres, and M. J. Lombardero. 1999. Climate and the northern distribution limits of *Dendroctonus frontalis* Zimmermann (Coleoptera: Scolytidae). Journal of Biogeography 26:1133-1145.