

# The relationship between local demographics and landscape epidemiology in the southern pine beetle

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## Introduction

- Dendroctonus frontalis* (Coleoptera: Scolytidae) is native to the southeastern US where it employs mass attacks to kill healthy native pines.
- Following a spring dispersal phase, beetles form a population of local aggregations (infestations) within the forest landscape. Individual infestations then have highly variable fates, from rapid extinction to high growth until dispersal the next spring
- Thus, the epidemiology of landscape populations involves birth rates and death rates of infestations (annual cycle) as well as local demographics of the beetles that comprise infestations (3-5 generations / year).
- We know relatively little about how local demographics are related to landscape epidemiology



## Hypotheses

- H1: The abundance of flying beetles during the spring dispersal phase predicts the number and initial size of infestations during summer.
- H2: Infestations that begin with a larger number of dispersing beetles have higher relative growth rates because mass attacks of trees are more successful in large aggregations.
- H3: Factors that influence tree oleoresin defenses (e.g., pine species composition, thinning, and climatic variation) can influence the landscape epidemiology of *D. frontalis*.

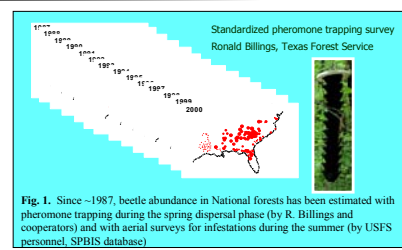


Fig. 1. Since ~1987, beetle abundance in National forests has been estimated with pheromone trapping during the spring dispersal phase (by R. Billings and cooperators) and with aerial surveys for infestations during the summer (by USFS personnel, SPBIS database)

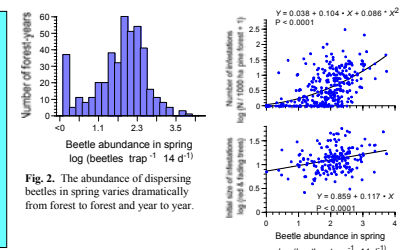


Fig. 2. The abundance of dispersing beetles in spring varies dramatically from forest to forest and year to year.

Fig. 3. The number of infestations in summer, the initial size of infestations, and the variance in size and number of infestations, were positively related to the abundance of beetles during spring.

**H1: Supported.** However, there is large variation in the size and number of infestations associated with any given abundance of dispersing beetles. Functions in Figs. 3 were used to parameterize a model of landscape epidemiology in which replicate populations of infestations were generated (with stochastic variation) based on the modal abundance of dispersing beetles, and then each infestation was allowed to grow at rates determined by the frequency distributions of tree resin flow across the forest (Figs. 8,10) and the effects of tree resin on beetle reproduction (Fig. 4)

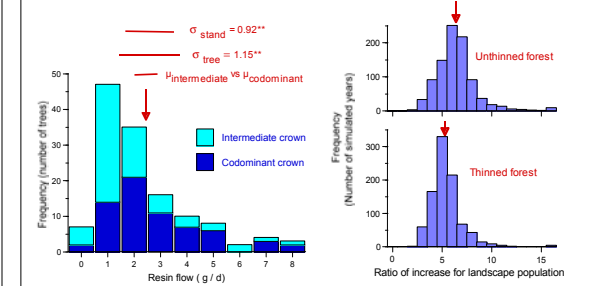
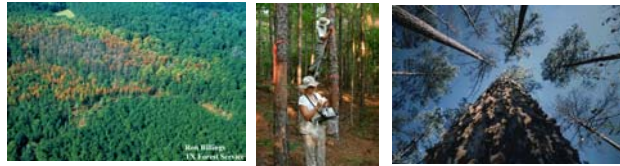


Fig. 8. Resin flow of *Pinus taeda* varied among stands within a forest, among crown classes within stands, and among trees within crown classes.

Fig. 9. The average growth of simulated beetle populations was about 15% lower in a hypothetical thinned forest (that lacked any trees with intermediate crowns) compared to a hypothetical unthinned forest (1:1 codominant: intermediate).

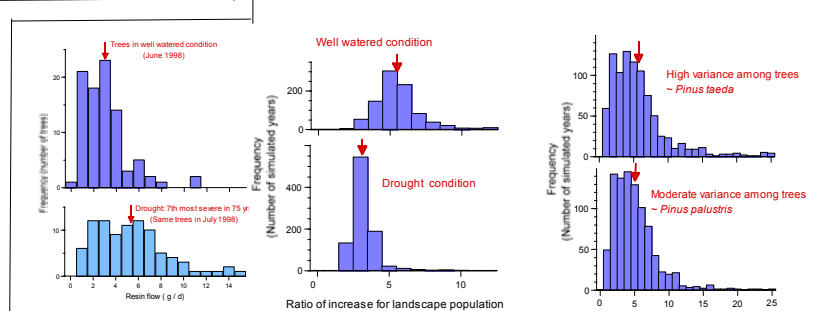


Fig. 10. Average resin flow of *Pinus taeda* almost doubled during a moderately severe drought in 1998 (Lombardero et al. 2000)

Fig. 11. The average growth of simulated beetle populations was nearly halved by increases in resin flow corresponding to Fig. 10.

Fig. 12. The average growth of simulated beetle populations was increased by 12% as a result of increased variance in resin flow among trees (as we have observed sometimes in comparisons of *P. taeda* and *P. palustris*).

**H3: Supported in part.** Our model indicates that changes in the mean or variance of tree resin flow can influence the growth of beetle populations in a forest landscape. Increases in the average resin flow, or increases in the variance among trees, both tend to increase population growth. However, of the three scenarios evaluated here, tree water status was the only one that generated large effects in population growth. We are unable to explain the common empirical observation that stands of *P. palustris* sustain less infestations than stands of *P. taeda*: none of four studies have indicated higher average resin flow in *P. palustris* and the differences in variance do not seem sufficient to explain the pattern.

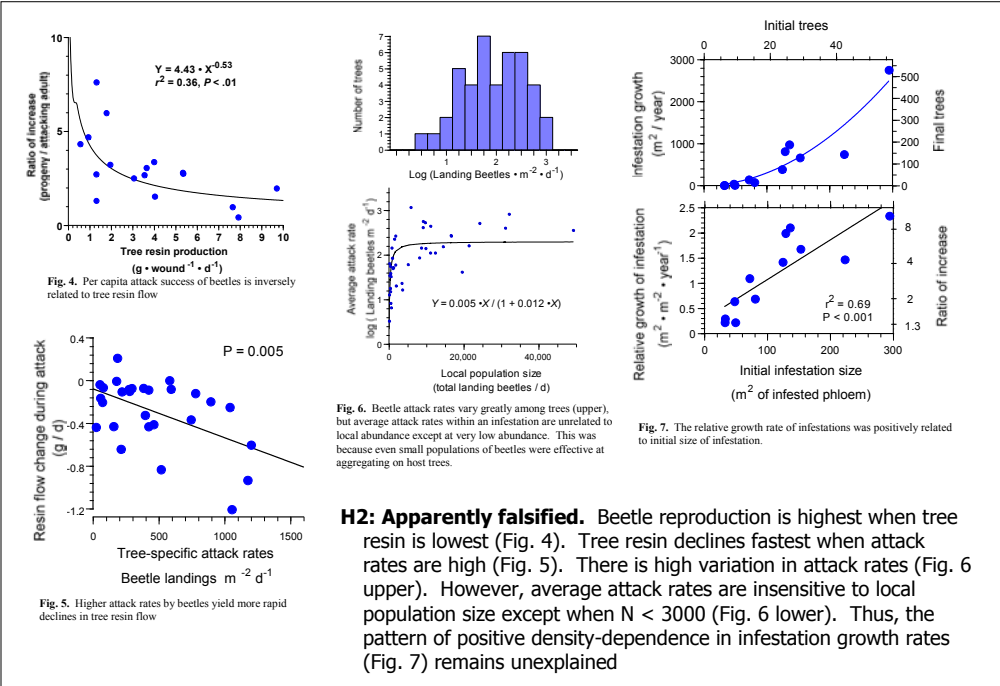


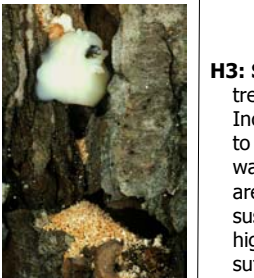
Fig. 4. Per capita attack success of beetles is inversely related to tree resin flow

Fig. 5. Higher attack rates by beetles yield more rapid declines in tree resin flow

Fig. 6. Beetle attack rates vary greatly among trees (upper), but average attack rates within an infestation are unrelated to local abundance except at very low abundance. This was because even small populations of beetles were effective at aggregating on host trees.

Fig. 7. The relative growth rate of infestations was positively related to initial size of infestation.

**H2: Apparently falsified.** Beetle reproduction is highest when tree resin is lowest (Fig. 4). Tree resin declines fastest when attack rates are high (Fig. 5). There is high variation in attack rates (Fig. 6 upper). However, average attack rates are insensitive to local population size except when  $N < 3000$  (Fig. 6 lower). Thus, the pattern of positive density-dependence in infestation growth rates (Fig. 7) remains unexplained



## Conclusions

- The number and probabilistic fate of beetle infestations in a forest landscape can be conceptualized in terms of initial numbers of beetles during spring dispersal, aggregation of beetles into a population of local infestations, and autonomous dynamics of those infestations through the remainder of the year (with local growth rates being influenced by the mean and variance in tree resin defenses).
- The existence of strong positive density-dependence (Fig. 7) must have a strong impact on landscape epidemiology but a heretofore promising explanation for this allee effect no longer seems valid (Fig. 6).
- Similarly, we remain unable to explain why *Pinus palustris* sustains fewer infestations than *P. taeda* (Fig. 12).

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