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Species diversity lessens susceptibility to budworm

Eldon Eveleigh—a research scientist at Natural Resources Canada - Canadian Forest Service's Atlantic Forestry Centre (CFS-AFC)—has demonstrated that the more diverse the species mix of a forest stand is, the lower the level of damage that feeding by spruce budworm (*Choristoneura fumiferana*) will cause to balsam fir (*Abies balsamea*) (Eveleigh et al. 2007). Eveleigh has recently concluded a long-term study in New Brunswick's Acadian forest ecosystem that revealed a remarkably complex yet highly flexible food web on balsam fir. This food web changes consistently and dramatically both in time and space in response to natural changes in the abundance of budworm, one of North America's most eruptive and devastating forest pests.

Eveleigh and colleagues documented and analyzed 14 years of field data on the composition and structure of the balsam fir food web at three plots varying in landscape (resource) structure over a budworm outbreak and decline. The study revealed an assemblage of species interacting at five conventional trophic (feeding) levels: one host plant; six herbivores; 66 primary parasitoids, 21 primary entomopathogens; 23 secondary parasitoids, one secondary entomopathogen; and six tertiary parasitoids. This parasitoid–entomopathogen assemblage is probably the most complete and diverse described to date for any insect herbivore community, rivaling that of many tropical food webs in terms of the total number of parasitoid species.

The study also revealed that, when budworm populations are high, there were more primary parasitoids (parasitic insects that attack and kill insect herbivores) and hyperparasitoids (parasitic insects that attack and kill other parasitic insects) that feed either on one host species (specialist parasitoids) or on several host species (generalist parasitoids) in mixed-species forest plots than in single-species forest plots. This greater food-web flexibility in mixed-species plots—and given that the greater plant diversity in mixed-species plots supports more types and numbers of alternate and alternative host species—plays an important role in minimizing budworm damage in mixed-species plots. In fact, food webs in the two plots with the most diverse species mix also showed lower peaks in budworm density than the plot that was most uniform in plant species composition. Thus, this study supports earlier published observations that the more diverse the species composition of a forest, the less impact budworm feeding will have on balsam fir.

Overall, the results have important implications for some key ecological issues:

(1) Biodiversity and conservation—the study provides clear evidence that food-web structure and complexity is not static in time and space but changes dramatically and consistently with natural changes in the density of the major food-web player, in this case, the spruce budworm. Despite its negative economic impact on the forest, budworm is an integral and vital player in the forest ecosystem. To understand how ecosystems function and how they can be affected by natural disturbances such

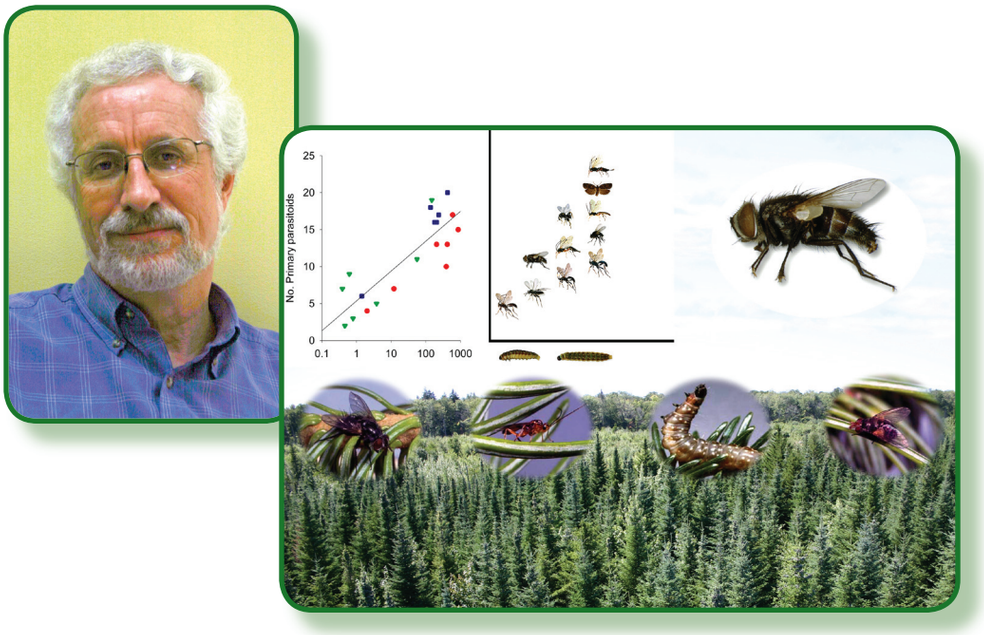
Diversity and susceptibility . . .

as insect outbreaks, the network of trophic interactions (biostructure) in the ecosystem, not just the diversity of species contained therein, must be understood.

(2) Population and food-web ecology—the study provides new insights into the strong relationship between individual species' dynamics and food-web ecology; it argues for an integrative approach to gain a better understanding of these traditionally separate branches of ecology.

(3) Forest and pest management—the study provides a plausible mechanism for forest composition effects on insect-pest populations. The results show that practices such as large-scale monoculture that homogenize the base of the food web could inhibit the buffering effect of generalist parasitoids and, in combination with reducing vegetative biodiversity that supports important alternate/alternative hosts for parasitoids, could lead to more severe and costly outbreaks of insect pests, such as budworm, in these areas.

Eveleigh, E.S., McCann, K.S., McCarthy, P., Pollock, S.J., Lucarotti, C.J., Morin, B., McDougall, G.A., Strongman, D.B., Huber, J.T., Umbanhowar, J., and Faria, L.D.B. *2007. Fluctuations in density of an outbreak species drive diversity cascades in food webs. Proceedings of the National Academy of Science* ***104****: 16976–16981.*



Above left: Dr. Eldon Eveleigh; above right: created by D.A. Perry; front page photo taken by C.I. Adam

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