

# EFFECTS OF ECOSYSTEM DISTURBANCE ON POPULATION DYNAMICS OF INSECTS AND DISEASES OF BOREAL FORESTS

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We have completed six years of research on the effects of ecosystem disturbance on population dynamics of insects and diseases of boreal forests in both interior and south-central Alaska. Studies that were ongoing in 2002 are summarized below.

Study 1. Monitoring of folivorous and phloeophagous insect populations was continued in the Bonanza Creek Experimental Forest. Population monitoring was started in 1975 and has continued annually into the current year 2002. During this 27-year period, populations of the spear-marked black moth and large aspen tortrix continued outbreak levels on a 10-year cycle until 1980, when population levels remained low. In comparison, high populations of the eastern spruce budworm, larch sawfly, and aspen leaf miner were observed after 1990. Annual temperatures fluctuated on a 10-year cycle before 1980, at which time they became abnormally higher until the year 2000. In interior Alaska, high populations of *Ips* engraver beetles were recorded in the early 1980's, whereas in south-central Alaska, high populations were evident from 1995 to 2000. Populations of the spruce beetle have been extremely high in south-central Alaska from 1980 to 2000, but have declined since then. Spruce beetle populations in interior Alaska have always been at low levels, probably because of behavioral characteristics that differ from populations in south-central Alaska.

Study 2. Research into the mechanisms by which spruce beetle populations transform from an endemic state to an eruptive state were conducted in south-central Alaska. The major focus was on the beetle's colonization behavior, in which they use mass attacks, mediated by pheromones, to overwhelm tree resistance. Trees are capable of resisting small numbers of attacks, but if sufficient beetles can be rapidly attracted to a tree, no level of defense is adequate to resist successful colonization. The hypothesis that selective pressures on individual beetles may change as a function of their population densities was supported by the following: At low densities there may be strong selection for beetles to avoid healthy trees, as initial colonizers are unlikely to elicit arrival by enough conspecifics to overwhelm tree defenses; conversely, at high densities there is little pressure to display discriminating behavior as entry into almost any spruce tree is likely to be accompanied by mass attack and successful colonization. According to this model, if an event such as several years of warm weather, drought, or defoliation results in an original population increase, then beetle epidemics persist indefinitely as they functionally expand their own food supply.

Study 3. Research was conducted in south-central and interior Alaska to identify stain fungi associated with the spruce beetle and *Ips* engraver beetle. Adult beetles that were initiating new attacks on previously uninfested spruce trees were used to isolate fungi. These fungi were cultured on 1.5% malt extract agar, to which was added a bacterial antibiotic. Fungi were classified by hyphal morphology and by fruiting structures in the anamorph stage. Eight different fungal species were found associated with the spruce beetle. The most common species was *Leptographium abietinum* (70%). Other fungal

species were: *Ophiostoma* species A (10%), *Pesotum* species F (5%), *Ophiostoma* species D (5%), *Pesotum* species C (5%), *Ophiostoma piceae* (3%), *Ophiostoma cainii* (1%), and *Ophiostoma* species E (1%). Seven species of fungi were associated with *Ips* engraver beetles: *Ophiostoma bicolor* (36%), *Leptographium abietinum* (36%), *Ophiostoma* species A (4%), *Pesotum* species F (3%), *Ophiostoma piceae* (2%), *Ophiostoma cainii* (2%), and *Pesotum* species C (2%). *Ophiostoma bicolor* was not associated with the spruce beetle. The second phase of this study will quantify the variation of these fungi in endemic and eruptive populations of beetles.

Study 4. Various species of arthropods associated with endemic and eruptive populations of spruce and engraver beetles were collected and identified from south-central and interior Alaska spruce forests. This study was first established in the Bonanza Creek Experimental Forest in interior Alaska in 1996 in several stands of white spruce that were mechanically disturbed to simulate a bark beetle attack, e.g., trees were felled, trees were girdled at the base but left standing, and undisturbed control trees. In south-central Alaska, the study was initiated in 1998 on the Chugach National Forest, in cooperation with the US Forest Service. The study was established in areas of Lutz spruce that were recently heavily infested by spruce beetles. Associated arthropods were collected in the study sites using pit-fall traps, Lindgren funnel traps baited with bark beetle and wood borer semiochemicals, and screen traps placed on the lower trunks of standing live trees. More recently, a similar study was started in 2002 on the Kenai National Wildlife Preserve, in cooperation with the US Fish & Wildlife Service. Thus far, three new species of weevils (Curculionidae) were found in the interior study sites, plus many species of other insects and an abundance of arachnids (spiders). Many of these specimens are still being identified.

Study 5. Measurement of the effects of various ecosystem disturbances on the diversity of bark and wood-boring beetles continued in interior Alaska. The effect of timber harvest, i.e., clear-cutting and shelterwood harvest, fire, the fringe area surrounding a fire, and undisturbed stands of white spruce were the types of ecosystem disturbance that was measured on both upland and river bottom sites. Populations of bark and wood-boring beetles were measured 1 year after the disturbance and at 5-year intervals thereafter. Populations have been monitored for 15 years with the 20 year measurements to be made in 2003. The most dramatic change was an increase in the number of various wood-boring beetles in the fringe area of burned stands 1 year post-disturbance, but a decrease thereafter, until 15 years post-disturbance when the number of different species of bark beetles and wood borers were similar in both undisturbed and disturbed sites.