Landscape drying, spruce bark beetles and fire regimes on the Kenai Peninsula, Alaska

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Visitors and residents alike often complain that it rains frequently on the Kenai Peninsula, Alaska. In truth this is an illusion; the rainfall is light and it doesn't accumulate. Indeed, the western Kenai lowland is actually quite dry because it is situated in a strong rain shadow from the Kenai Mountains on the east side of the Peninsula. When 17 inches of annual precipitation fall on Sterling in the center of the Kenai lowland, as much as 120 inches fall on the eastern (Prince William Sound) side of the Peninsula at the port of Whittier.

Because the western Kenai is so dry, the landscape is extremely sensitive to increased summer drying which has occurred in recent decades. This drying is quite visible in the annual water balance at the city of Kenai (Fig. 1), for example, and has resulted in falling lake levels and the loss of many small ponds and wetlands (Klein et al. 2005).

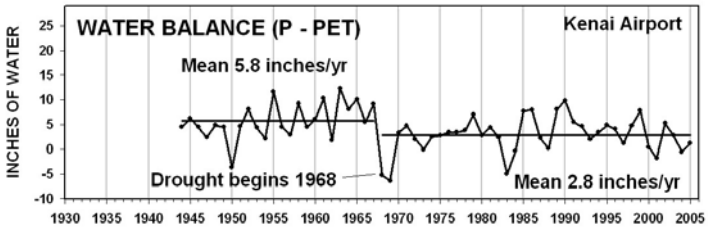

Fig. 1. The water balance, which is the difference between precipitation (P) and potential evapotranspiration (PET), represents the water available for stream flow, groundwater recharge and biomass growth. Warmer summers since 1968 have increased evapotranspiration, even though precipitation has remained unchanged.

Prior to the warming of North Pacific sea surface temperatures in 1977, several warm El Niño summers typically would initiate an outbreak of the spruce bark beetle (*Dendroctonous rufipennis* or SBB), which would subsequently be extinguished by several cool La Niña years. Since 1977, longer runs of warm summers have allowed SBB populations to grow exponentially, often by shortening the 2-year beetle life cycle to 1 year. Warmer winters have facilitated greater overwinter survival of larvae and adults. The 11-year run of warm summers from 1987 to 1997, for example, produced the largest SBB outbreak ever recorded in North America (Figs. 2 & 3). The outbreak ended only when the beetles had exhausted available host material, not because the summers had cooled.

For the past 2500 years there has been no connection between SBB outbreaks and wildfire. Our fire history and SBB outbreak history studies indicate that white/Lutz spruce (*Picea glauca and P.* x *lutzii*)forests burn with a mean fire return interval (MFI) of 400-600 years, whereas the beetles thin the forests every ~50 years (Berg and others, this proceedings; Berg and Anderson 2006; Berg et al. 2006). Black spruce (*P. mariana*) – which is not significantly affected by the SBB - provides the dominate fire regime on the Kenai, with an MFI of ~80 years (De Volder 1999).

Although Kenai beetle-killed forests did not burn in the past, the climate is drier now and there have been several fires in newly-killed forests with red needles. A decade has passed since much of the forest was killed, and none of the forecasted conflagrations have so far materialized. The presence of much down timber, however, makes fires difficult to fight when they do occur,

and the brittle dead branches increase the risk of spotting in wind-driven fires. Lush stands of tall bluejoint grass (*Calamagrostis canadensis*) have proliferated under the open dead spruce canopies. Fire managers thus still consider the thousands of acres of beetle-killed spruce forest a major wildfire liability, especially during warm and dry periods in late spring before vegetation green up when the bluejoint grass is highly flammable.

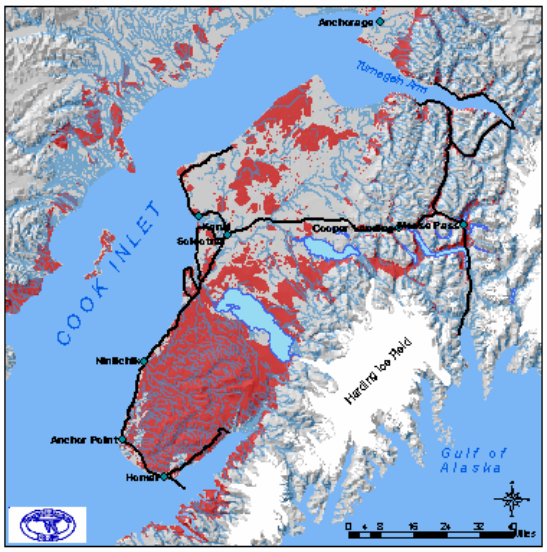

Fig. 2. Cumulative spruce bark beetle mortality 1989-2002 is 1.1 million acres (429,000 ha). Cumulative mortality for south-central Alaska is 3 million acres (1,200,000 ha) for the same period. Spruce bark beetle mortality was higher on the southern Kenai because of monospecific stands of mature white/Lutz spruce where the time-since-last-fire averaged 600 years. The northern Kenai has a much more heterogeneous landscape, with large areas of frequently burning black spruce and younger white spruce stands.

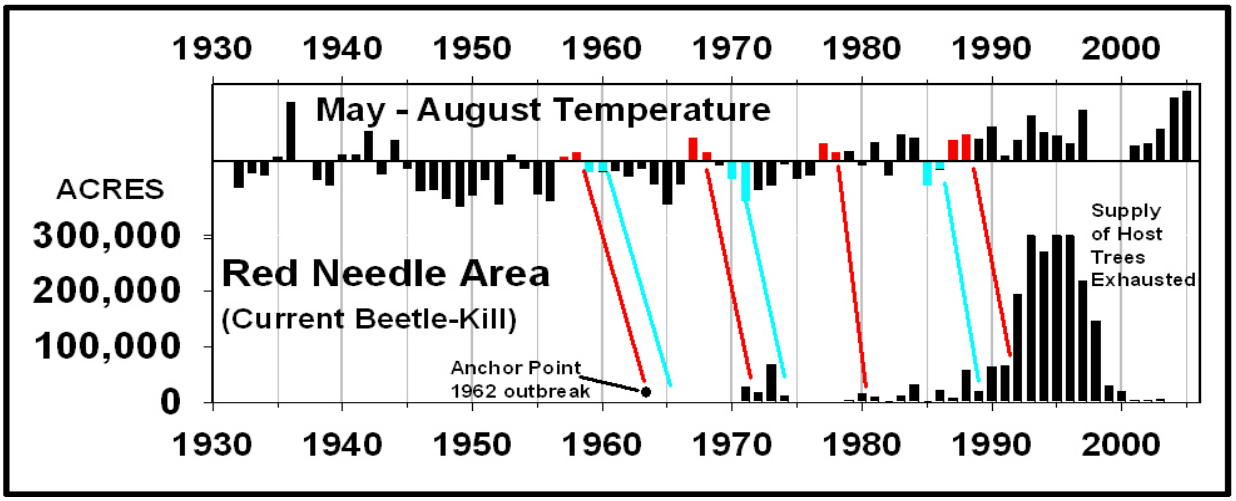

Fig. 3. Annual summer temperatures (Homer) and annual spruce bark beetle mortality in white/Lutz/Sitka spruce forests on the southern Kenai Peninsula. Forest mortality was estimated from US Forest Service aerial surveys beginning in 1971, as well as ground-based field reports beginning in 1950. May-August temperatures are normalized departures from the mean. Red color indicates runs of two or more warm summers that initiated spruce bark beetle outbreaks. Blue color indicates runs of cool summers that apparently extinguished or retarded outbreaks. Mortality has been at background levels since 2001 in spite of warm summers due to absence of mature spruce trees.

The warmer summers are drying out Kenai wetlands. Peatlands that have been wet *Sphagnum* fens for 8-13,000 years are for the first time being invaded by woody shrubs and black spruce. In the past these wetlands were fire excellent firebreaks; as the climate dries they are becoming fuel bridges (Fig. 4).

With a warmer climate we expect that bark beetles will kill white/Lutz spruce before continuous canopy mature conifer forests can be re-established, and that the resulting grasslands and hardwood forests will provide a more heterogeneous vegetation cover in upland areas. The absence of conifers will make the upland areas more fire resistant, at least after spring green up. The lowland areas, on the contrary, will become more flammable with increased shrub and black spruce cover. The human population of the Kenai is growing at 2.2% per year, and much land has been subdivided after salvage logging of beetle-killed spruce. Most fires on the Kenai are human-caused, and increased fire suppression activity will probably be necessary in the expanding urban-wildland interface.

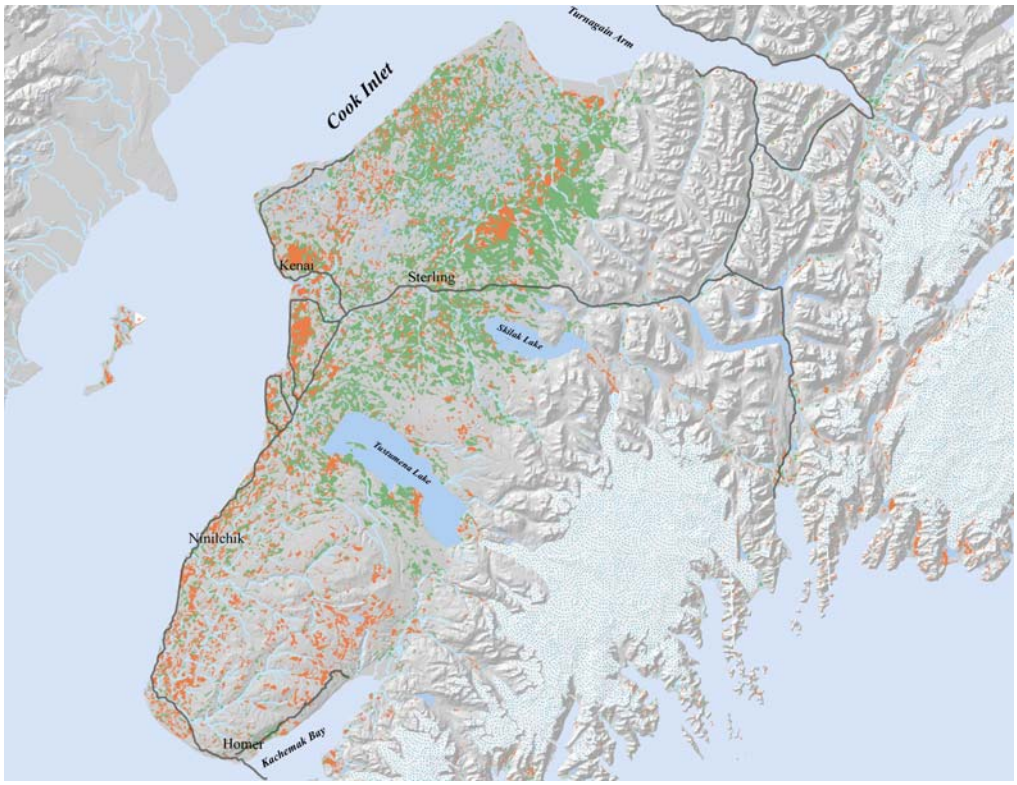

Fig. 4. Wetlands (orange) and black spruce forest (green) on the Kenai Peninsula. As the wetlands continue to dry with climate warming, they will be converted to shrubs and black spruce, providing greater continuity of the high flammable black spruce fuel type.

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