Ancient bent trees at treeline are straightening up, tell of climate change

by Ed Berg

Ed Berg with release mt hemlock. USFWS.

You may not have noticed it, but treeline is going up on the Kenai Peninsula. Some years ago Yule Kilcher, a Swiss homesteader in the Homer area, pointed out to me the rising treeline on the mountains across Kachemak Bay. Since then I have sampled spruce trees at many treeline sites from Kachemak Bay to the Mystery Hills and have always found the highest trees to be young in age.

A rising treeline is not surprising in Alaska, given our accelerating climate warming. Treeline probably began to rise about 150 years ago with the end of the Little Ice Age. In the 1850s Kenai mountain glaciers began to pull back, and shrubs and black spruce forest began to invade the extensive sphagnum moss peatlands on the Kenai lowlands. The last couple of decades have seen much more recruitment of seedlings above treeline, the glaciers are pulling back faster (e.g., Portage glacier), and ponds and close-basin lakes are drying up from increased evapotranspiration during our record warm summers. The warming is speeding up, it would seem.

Recently we have been studying another barometer of climate change on the Kenai: the disappearance of "krummholz" tree growth at alpine treeline. Krummholz is German for "twisted wood," which refers to the more-or-less horizontal growth of trees at wind-swept alpine treeline sites. Krummholz trees are often found hunkered down in swales and hollows where the snow is deeper and lasts longer than on the open tundra slopes. The twisted horizontal growth occurs when the normally upright tree tip or leader is blasted by wind-driven ice crystals during the winter. This winterkill of the leader prunes the top of the tree and promotes fuller growth of lower branches, a phenomenon well known to gardeners.

On the Kenai we usually see a band of mountain hemlock above spruce treeline. When you drive through the mountains on the Sterling Highway you can see the darker green hemlock (with no beetle kill) above the lighter green white spruce, and at Turnagain Pass you are right up in the mountain hemlock zone.

On an exposed slope at the top of the mountain hemlock zone we often find a krummholz belt of bent over hemlocks snaking along the ground. These twisted gnomes are very slow growing and can be very old; we have tree-ring dated krummholz trunks north of the Skyline Trail to the 1500s, even though these trunks are only five or six inches in diameter.

Now, here are the key observations: Kenai mountain hemlocks aren't doing krummholz anymore. Baby hemlocks now grow straight up at treeline and have probably been doing so for much of the 20th century, to judge from the upright saplings growing amidst the krummholz ancients.

Furthermore, we now see old krummholz trees turning upright and producing normal vertical trunks. Trunks may hug the ground for as much as eight or ten feet and then sweep upward into the vertical mode. Trees normally grow upright in response to gravity, because cells in the growing leader are gravity-sensitive and will elongate opposite the force of gravity. This means that each year a tree will try to put out an upright leader, even if it gets pruned back every winter.

When we see many krummholz trunks turning upright, and their offspring all growing upright, we can infer that climatic conditions have somehow moderated or ameliorated to allow this upright growth. Ulti-

mately this amelioration is probably due to increased temperature, but exactly how this increase translates into improved tree growth needs further study. For example, warmer winters should produce more snow (and wetter snow) which could protect treeline trees from wind damage, and provide more water for spring growth. Reduced winter wind would obviously reduce wind damage, although I am not sure that warmer winters would necessarily have less wind.

Plant physiologists have long pondered the origin of treeline. Just why do trees stop growing at a certain elevation on a particular mountainside? One popular theory is that the growing season becomes too short for needles to form a thick enough waxy skin or cuticle. If the cuticle is too thin, the needles will lose too much water during the spring when they warm up and become active, but are unable to pull up water from the frozen soil. This "spring desiccation" problem could be substantially reduced with warmer summers and a longer growing season that allowed a protective cuticle to be fully formed.

Whatever the climatic cause, treeline will be higher for the next generation of trees on the Kenai. Indeed, it appears that white spruce has essentially leap-frogged over the narrow mountain hemlock zone, krummholz and all, and is starting to grow above the hemlock zone. We recently observed a dramatic example of this rapid advance in the headwaters of Mystery Creek, north of the Skyline Trail. The mountain hemlock krummholz zone is well developed on the northeast flank of the mountain at 650 to 800 meters elevation. For at least 100 meters above the top of the hemlock krummholz we saw abundant white spruce seedlings (up to three feet tall), and lesser numbers of hemlock seedlings.

A really severe, low-snow winter would probably kill these seedlings, but we saw no cohort of dead seedlings that would suggest that such a winter has occurred in recent years. Our winters have been dramatically milder since 1977, when North Pacific sea surface temperatures warmed, following the half-century cycle of the Pacific Decadal Oscillation (PDO). Most of the seedlings that we are seeing above treeline have probably established in the post-1977 warm period.

In California U.S. Forest Service ecologist Connie Millar has studied krummholz changes with whitebark pine in the high Sierras, and has correlated these changes with 20th century climate patterns. She found that krummholz whitebark pines produced vertical branches ("flags") primarily during the period of 1945 through 1976, when the PDO was in its cool phase. Unlike the Kenai, the vertical branching in the Sierras has declined substantially during the recent warm phase of the PDO, from 1977 to 1998.

Chris Fastie, who worked with me as post-doc at the Kenai Refuge in the mid-1990s, and his wife Andi Lloyd have been studying rising treeline at various sites in Interior Alaska. They too have noted a decline of new krummholz in recent decades, and that young trees at and above treeline are mostly growing upright.

Studying treeline changes on the Kenai would make an excellent thesis project, for a hearty foot-propelled graduate student who would enjoy spending a summer or two in the alpine. To get such a study launched, I am looking for more treeline sites that show upturning krummholz trunks (flags), as well as seedling recruitment above treeline. Hunting season will soon be opening in the high country, and I would greatly appreciate any tips from treeline hunters and hikers who might find some good examples in their travels. Photos and GPS coordinates would be especially useful.

Connie Millar's treeline studies in the California Sierras are summarized at http://www.x-cd.com/mcss04/papers/P47.pdf. Chris Fastie and Andi Lloyd describe their Alaska tree line studies at http://cr.middlebury.edu/biology/treeline/index.htm.

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