Fir Waves in the High Peaks Region of Adirondack Park

Disturbances can, and should, also be viewed as important components of natural ecosystems. Single tree blow downs that create light gaps in a climax forest are important in creating new opportunities for regeneration for a small patch of forest. Similarly seasonal flooding along rivers selects against seeds, seedlings, and tree species intolerant of periodic inundation with water.

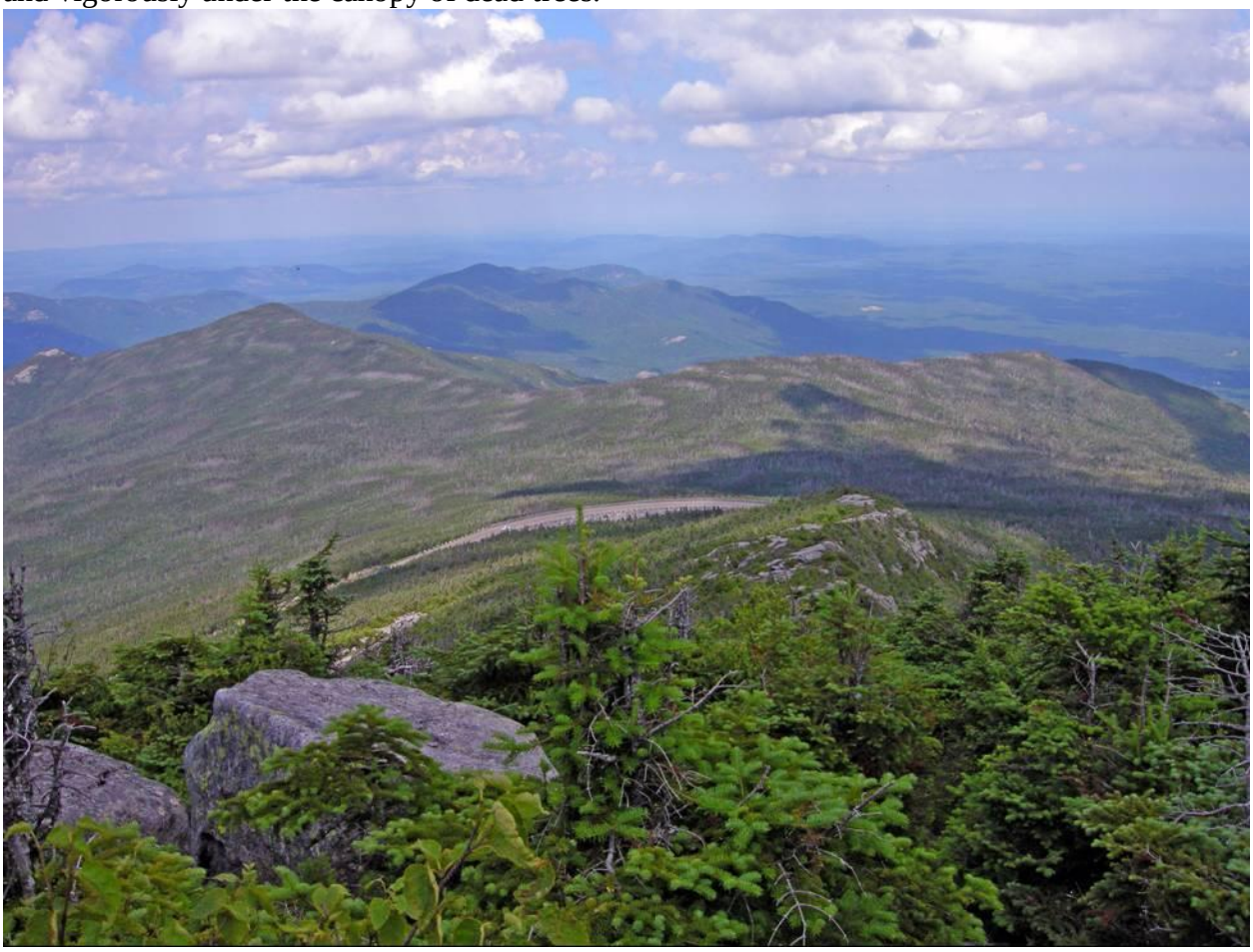
Adirondack Park is impregnated with the aroma of balsam fir throughout much of its six million acres. The aroma is reminiscent of the Christmas season or of wilderness and rustic conditions that are found in the Adirondacks. At lower elevations within the park balsam fir is a common associate in the maple, beech, sugar maple, eastern hemlock forest, but is not at all abundant. It rarely flourishes except on the borders of some wetlands and forest edges.

Balsam fir gradually becomes more abundant (2500-3500 ft) and then dominant with spruce (above 3500 ft) along elevation transects. Length of the growing season, depth of the soil, and water availability decline along this transect. Balsam fir and red spruce with their conifer needles and thick waxy cuticle are well-adapted to the climatic conditions of these montane areas. Tree growth also declines with elevation and then above 4500 ft the fir-spruce forest is shaped by the harsh winds, intense sunlight, blistering cold, snow and ice loads. This forest of twisted wood and wind-shaped trees is referred to as krummholz. Balsam fir and red spruce growing in exposed areas on the mountains have bluer needles that are bundled more densely around short twigs than their lower elevation counterparts.

The ecology of the balsam fir climax forest in subalpine zones is driven by a process of continual disturbance involving multiple factors. Aerial views of these forests highlight a pattern of silver and green bands in crescent waves across many of New England's mountains (see Figure FIR WAVES below). The balsam fir forest in subalpine zones undergo a cyclic process of ecological succession the results in migrating waves of dying and regenerating fir forest. The cause of this unique ecological process appears to be a unique combination of species interactions, climate, topography, and seasonality in fir forests near 45 degrees N in North America and Japan. Southern humid air masses and cold dry polar air interact at this latitude to perpetuate fir waves.

Standing under the canopy of balsam fir on Whiteface Mountain, one is impressed with the dense canopy from uniform-sized trees and a forest floor rich in conifer needles with few herbaceous plants. There are the occasional American mountain ash, mountain maple, paper birch, and green alder scatter along forest openings and with in the forest. The silver bands in fur waves consist of balsam fir graveyards. In these areas, bark has fallen off the dead balsam fir to reveal the silvery sheen of the underlying wood. Sunlight is intense as dead branches and trunks weakly filter the light. On the ground is a carpet of young balsam seedlings and saplings. You can cross through the graveyard in a matter of meters. With each step the young firs become thicker, taller, more rapidly growing and impenetrable to walk through until you arrive at another canopy of uniform-sized fir trees. From the air, Whiteface and nearby Esther Mountains are zebra-striped with these curvaceous lines of silver and green. Over the years, these waves move with the prevailing winds creating new graveyards and regenerated fir forests.

Figure FIR WAVES. Balsam fir forests at high elevations in the Adirondacks have an unusual successional pattern that results in bands of dead trees called fir waves. Firs regenerate quickly and vigorously under the canopy of dead trees.



The causative agents of this pattern of death and regeneration in subalpine fir forests is not an infective pathogen that ravages the forest, but a natural interaction between the environment and biology.

The balsam fir graveyards provide a buffer between winds above the canopy and the young fir seedlings below. As the canopy disappears and light begins to penetrate to the forest floor, balsam fir seed banks begin to germinate forming a carpet of dark green on the graveyard floor. The seedlings grow rapidly in this environment as nutrients are being recycled and competition with other species is low. The soil in the mountain community remains thin and the flush of stem grow is supported by roots that form a flattened network just inches below the surface.

FIG. 1. Diagrammatic cross-section through a regeneration wave.

Figure 1 is from Sprugel 1976.

The cause of death in the fir graveyard is not immediately evident. Was it old age? Certainly not, ring counts for these trees suggest they should be in the hay day of their youth. The oldest average age in mature subalpine fir canopies is less the 60 years although a few stands may live longer. Analysis of wood patterns, show an increase in partial annual rings prior to death of canopy firs (Marchand, 1984). Marchand suggests that this is a result of needle loss late in life.

Living canopy firs downwind of the graveyard are exposed to more intense environmental conditions. They face the prevailing winds in both summer and winter. Super cooled moist air rushes through the forest during the winter and collects on exposed fir branches. On contact, the super cooled water freezes immediately forming rime ice. Rime ice photographs in the weather station on top of Whiteface Mountain are impressive. The ice accumulates thickly on the windward side forming intricate patterns. The scene is reminiscent of icy weaponry used by Mr. Freeze in batman comic books and films.

Rime ice shortens the life of needles and branches. They become brittle and fall prematurely from the fir. After a few rounds of winters rime ice, the photosynthetic capacity of the tree is diminished considerably. This loss of photosynthetic capacity starts a cascade of events that claims the life of this uniformed aged canopy. The winds of the high elevation forests throttle tree trunks back and fort, stretching and cracking roots that strain to hold the tree in place. In his Natural History article, Marchand recalls listening to the cracking of over strained roots while camping on Whiteface Mountain. Trees are built with wound repair mechanisms that work under most circumstances, but are compromised when the trees photosynthetic energy vault is empty. In compromised trees, bacteria and fungi invade the roots quickly and further compromise the health of the tree. Before long, the assault of rime ice, wind, bacteria, and fungi has claimed a new section of graveyard forest.

Fir waves run through the Adirondack forest with the assistance of rime ice and wind on the edge of waves. The phenomenon is clearly a disturbance that changes the shape, structure, and function of the balsam forest throughout time. But unlike a disturbance the resets a successional to an earlier, different community, the fir waves on Adirondack subalpine forest simply rejuvenated and regenerate the same species of climax forest.

Literature Cited:

Sprugel, D.G. 1976. Dynamic structure of wave-regernated *Abies balsamea* forests in north-eastern United States. Journal of Ecology 64:889-911.

Silvertown, J. and M. Dodd. 1999. Evolution of Life History in Balsam Fir (Abies balsamea) in Subalpine Forests Proceedings of the Royal Society: Biological Sciences 266:729-733.

Marchand, P.J. 1984. Dendrochronology of a fir wave. Canadian Journal of Forest Research 14:51-56.