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SEEING WHITEBARK PINE IN A NORTHERN ROCKY MOUNTAIN LANDSCAPE: NOTES FOR A FIELD TRIP

T. Weaver

ABSTRACT

The changing role of whitebark pine (Pinus albicaulis) *along an altitudinal gradient typical of the Northern Rocky Mountains (USA) can be seen from the gondolas at the "Big Sky" resort near Bozeman, MT. Whitebark pine appears mostly as seedlings in the lowest zone (7,500 to 8,500 ft), becomes increasingly important in the canopy between 8,400 and 8,900 ft, assumes climax dominance in the woodland zone (8,900 to 9,300 ft), and maintains that dominance to treeline. On this gradient the mature tree's growth form changes from tall-lyrate, to shorter-spherical, to krummholz. The tree is seral in the lowest zones; frequent fires exclude it from canopies in the lowest zone, while low fire frequency gives it subclimax status higher (8,400 to 8,900 ft) in the zone dominated by subalpine fir* (Abies lasiocarpa) *at climax. Above 8,900 ft, whitebark dominates woodlands (formed, probably, when subalpine fir is excluded by cold) and krummholz (due, probably, to winter desiccation). Mountain pine beetles* (Dendroctonus ponderosae) *have killed much of the lodgepole* (P. contorta) *and whitebark pine in the area, and whitebark groves tend to be ringed with dead trees because the especially vigorous trees at grove edges are most susceptible. Cirque bowls on Lone Mountain demonstrate an inverted timberline at which conifers disappear downward, probably due to spring frosts.*

INTRODUCTION

The "Big Sky" a popular resort 50 mi south of Bozeman, MT, is an excellent site for an introduction to whitebark pine (*Pinus albicaulis*) in its Northern Rocky Mountain setting. One sees, there, altitudinal zones demonstrating all its major roles: in a relatively low-altitude band the tree is seral to subalpine fir (*Abies lasiocarpa*), in a middle band whitebark dominates woodlands, and in a higher band it forms krummholz. And the whitebark zone is accessible on a year-round basis—thanks to paved roads leading to the resort and gondolas that traverse the forest zone during both winter and summer seasons (phone 406-995-4211 for information).

This note summarizes observations made by participants in a whitebark pine symposium (March 31, 1989) and can guide professionals visiting the area at later dates. Its three sections describe the study area, vegetation phenomena best seen from the gondola, and landscape phenomena best seen from a road connecting the tops of the north (#1) and south (#2) gondolas. Readers guiding themselves through the area with these notes can use the gondola pylon altitudes (table 1) for orientation. They can find more detailed discussion of most phenomena discussed here in chapters of this proceedings on whitebark pine forests, cited here by author.

PREVIEW OF THE STUDY AREA

The "Big Sky" gondolas rise from 7,500 to 9,200 ft, and chairlifts proceed to 9,800 ft. As they rise, both gondolas cross a gradient in which the soils become rockier, the climate becomes cooler, stand-replacing fires become more infrequent, and a lodgepole pine-subalpine fir (*Pinus contorta-Abies lasiocarpa*) forest mosaic is replaced in turn by open woodlands of whitebark pine and a mosaic of krummholz and alpine grassland.

Geology

Lone Mountain is a conical peak (11,166 ft) built from clay-rich sedimentary beds of the quaternary. The peak dominates its landscape because, while the unconsolidated sediments around it have eroded away, its mass was baked to slate and supported by andesitic intrusions. The quaternary deposits are underlain by mesozoic and paleozoic sediments and precambrian metamorphics exposed at the edges of the Jack Creek/West Fork/Porcupine syncline to the north and south (Tysdal and others 1986).

Substrate

The trees at highest altitude grow on bedrock outcrops, while grassy areas between the spurs occupy substrates deposited by gravity (colluvium), glaciers (till), and water (alluvium). Lower on the slopes (under the gondolas), substrates are less often bedrock and more often glacial or alluvial (Hansen-Bristow and others, this proceedings).

Climate

Showers of more than 0.01 inch fall on about half of the winter days and a third of the summer days. Amounts

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Table 1—Distribution of current forest types, climax forest types, and environmental types under the "Big Sky" gondolas

Altitude	Current vegetation[1]	Climax vegetation[2]	South gondola	North gondola
Ft			*Pylon #*	*Pylon #*
9,200	WB/whortleberry	WB/whortleberry	lift top	
9,000	WB/whortleberry	WB/whortleberry		lift top
8,900	WB/whortleberry	WB/whortleberry	25	21
8,400-8,900	SAF, WB, LPP, wb[3]	SAF/whortleberry		
8,400	LPP/whortleberry	SAF/whortleberry	17	15
7,500	LPP/whortleberry	SAF/whortleberry	base of lift	base of lift

[1]Plants mentioned here are whitebark pine (WB, *Pinus albicaulis*), lodgepole pine (LPP, *Pinus contorta*), subalpine fir (SAF, *Abies lasiocarpa*), and grouse whortleberry (wb, *Vaccinium scoparium*).

[2]Forest environmental types are classified and described by Daubenmire and Daubenmire (1968) and Pfister and others (1977). They are named for the climax vegetation that occupies them. The name consists of the name of the dominant overstory tree, a slash, and the dominant understory plant. The current vegetation of a site of one environmental type can be climax or seral.

[3]While low-altitude subalpine fir sites are dominated by lodgepole, absence of fire in the highest subalpine fir sites allows species representing later seral stages to grow into the overstory.

deposited are likely similar all along the gondola transect, with an average of 3 inches per month in the winter and less than an inch per month in the summer. Average maximum temperatures in the woodland zone just below timberline are probably 20 to 25 °F in January and 65 to 70 °F in July. Average minimum temperatures in the woodland zone are likely 5 to 10 °F in January and 40 °F in July (Weaver, this proceedings).

Fire

Despite similar start frequencies, fire is relatively frequent at the altitude of the gondola base (because it spreads easily in an undissected landscape) and relatively rare in the ridged province at the altitude of the gondola top.

Climax Vegetation and Environmental Types

If it were climax—undisturbed for hundreds of years—the vegetation beneath the gondolas would range from subalpine fir forests (from the gondola base through the current canopy transition zone, 7,500 to 8,500 ft), to a whitebark pine woodland (8,900 to 9,200 ft) at the top (table 1). Near the gondola top (8,900 to 9,300 ft) climax vegetation alternates between whitebark pine woodland and meadow with the forest occupying bedrock ridge sites and the meadow occupying colluvial-alluvial valley sites as well as the south-facing slopes of Lone Mountain. From chairlifts above the gondolas one sees that a mosaic of krummholz and "alpine grassland" occupies stable areas on ridges, while cliffs and excessively drained talus intervene. Ecologists use climax vegetation as an indicator of environmental type (Daubenmire and Daubenmire 1968; Pfister and others 1977).

Seral Vegetation

Because fire is relatively frequent at the altitude of the gondola base, trees that invade after fire (lodgepole pine) often replace climax trees (subalpine fir) there. In contrast, fire is relatively rare in the ridged province at altitudes near the gondola top so the forests there are subclimax and open woodlands are near climax.

OBSERVING THE FOREST ZONE FROM THE GONDOLAS

The gondolas traverse two environmental zones occupied by three vegetation types. Most of the vegetation of the subalpine fir zone (7,500 to 8,900 ft) is seral. The whitebark woodlands (8,900 to 9,300 ft) are near climax. Within a few hundred feet above the gondola tops krummholz dominates the arboreal vegetation. The following paragraphs point out details best seen from the south gondola (#2).

The ski runs are very early seral with bare ground being invaded, below 8,950 ft, by lodgepole pine and, especially on north slopes and cold draw bottoms, Engelmann spruce (*Picea engelmannii*). While whitebark seedlings are common in forests all along the transect, there are essentially none in the ski runs.

In the lowest zone (7,500 to 8,400 ft) most current overstories are dominated by lodgepole pine, which colonized after fires of different dates.

1. Patches containing young (thinner) lodgepoles indicate recent fire, while those containing older (thicker) trees indicate more ancient fires. Lodgepole is recognizable by 2-inch needles in bundles of two and numerous compact, closed cones. While both subalpine fir and whitebark pine seedlings appear in the understory, fires of the past have removed the stands before they could occupy the overstory.
2. The oldest—longest unburned—patches occupy narrower valleys and steep north-facing slopes; their overstories contain subalpine fir, spruce, and old lodgepole pines. The subalpine firs have very pointed tops, the spruce have broader tops often with open cones, and both have flat needles less than 1 inch long.
3. If you look at distant slopes, especially from the bottom and top of the gondola, you will see patches with different textures: the finest textures are young stands, coarser textures indicate older stands, and the coarsest and most ragged-looking stands approach the climax condition.

4. If fire were excluded from this zone, forests in the area would be dominated by subalpine fir in the overstory and grouse whortleberry (*Vaccinium scoparium*) in the understory.

The middle zone (8,400 to 8,900 ft) is covered by relatively old subclimax forests because fires have been much less frequent in it.

1. Pines and pointed-topped subalpine fir are common in the overstory. Broader-topped spruce are relatively uncommon, except in draws.
2. At the lower edge of the middle zone the overstory pine is lodgepole. At the top edge, the overstory pine is whitebark. The two pines can be distinguished by their cones: lodgepoles bear many small, closed cones, while whitebarks bear a few 2- to 4-inch cones in the summer—or, in winter, no cones. While one usually associates the "lyrate" form with whitebark, the branches of some lodgepoles growing in this part of the gradient also fan upward, both here and in other areas.
3. The seral nature of the middle-altitude pines is seen from the fact that, while subalpine fir and spruce continue to thrive in the older stands of this zone, the pines are dying, and were doing so even prior to the recent bark-beetle epidemic.

Higher forests (8,900 ft to timberline) are dominated by whitebark pine.

1. Whitebark pine is climax here, apparently because the physical environment excludes trees that outcompete it in the two lower zones (Arno and Weaver, this proceedings).
2. While the whitebark pines were usually single stemmed in lower forests, many are either multistemmed or clumped here. This clumping derives, in part, from the fact that most were planted by Clark's nutcracker (*Nucifraga columbiana*), a bird which caches the seeds in groups of 1 to 30 for later use (Lanner, this proceedings; Tomback, this proceedings) and is secondarily increased by the tree's tendency to branch at its base (Weaver and Jacobs, this proceedings). I speculate that the increase in clumping is also due to the decrease in competition from closed forests to open woodlands.
3. The shallow structural roots of whitebark pine can be seen on overturned stumps and in cuts along the road between the tops of gondolas #1 and #2.
4. The white bark of the pine has a reddish tinge in winter. Does anthocyanin protect the bark chlorophyll, as it does the chlorophyll in many spring leaves?
5. Nonforest vegetation above 8,900 ft consists of alpine grassland and tundra interfingering characteristically with the subalpine forest (Arno and Weaver, this proceedings).

OBSERVING "BIG SKY" LANDSCAPE ECOLOGY

From the road between the tops of gondolas #1 and #2, one can review the position of whitebark pine forests in a landscape typical of the Northern Rocky Mountains.

Erosion bares steep rock at high altitude and deposition rounds lower slopes and levels valley bottoms. The top of the north gondola (#1) lies at the base of one of the most spectacular glacial cirques in the area. In the bottom of the cirque, just above the top of the north gondola, is a rock glacier, an actively moving mass of rock and ice which models the glacier that originally filled the bowl. The buildings at the base of the gondolas are built on till deposited by the large glacier, which flowed from the cirque during the pleistocene.

The vegetation zones in the high-mountain landscape can be conceived of as more-or-less horizontal zones, including, from the top down:

1. An upper forest-free zone dominated by rock outcrops, talus slopes, and grassy tundra.
2. A zone in which forests are interspersed with nonforests. Whitebark pine forests occupy the rocky ridges. The ridges provide a stable, relatively fire-free site suitable for pine growth. The valleys between may be cleared by avalanches or cold air draining into them from above.
3. The whitebark woodland zone begins in the ridge and valley zone and may extend slightly below it (approximately 8,800 ft and above).
4. The zone in which whitebark pine is codominant with subalpine fir late in succession is detectable from its uneven "ragged" look. The existence of this zone also depends on a low fire frequency attributable to the valley-ridge structure in the landscape (approximately 8,400 to 8,900 ft).
5. Below 8,400 ft the valley broadens so that the spread of fire is less inhibited by the valley-ridge structure. As a result, one sees coarse-grained patches of relatively old trees that burned long ago interspersed with fine-grained patches of young trees on sites that were more recently burned.
6. At successively lower altitudes below the gondola base (7,500 ft), one sees zones of Douglas-fir (*Pseudotsuga menziesii*) and grass-shrubland never occupied by whitebark pine.

Changes in substrate may also affect whitebark distribution. While the whitebark trees near timberline on Lone Mountain are growing on slates, many sandstones, and most of the precambrian metamorphics, whitebark pine avoids limestone in our area (Weaver and Dale 1974) and is generally replaced on limestone outcrops by limber pine (*Pinus flexilis*), subalpine fir, or Douglas-fir.

Many of the pines seen from the gondola are dead. Most of the dead trees were killed by the pine bark beetle (*Dendroctonus ponderosae*) (Bartos and Gibson, this proceedings).

1. A survey of the valley below demonstrates the breadth of this attack.
2. While many of the trees with a phloem layer thick enough to support the beetle (larger diameter trees) are dead, thinner trees often escape beetle attack. I point to two resultant phenomena:

    a. Elimination of lodgepole (thick trees) from the overstory probably favors whitebark pine (thin trees) in the understory and may allow whitebark pine to dominate sites that would otherwise have succeeded more rapidly to subalpine fir.

b. Due to lesser competition, trees at the edge of groves are larger than those in the center. As a result they have thicker phloem, are more readily attacked by the bark beetle, and die. I attribute the fringe of dead trees around the grove north of the north gondola (#1) to this phenomenon.

Near timberline, trees are absent from interridge areas because of avalanches or frost damage due to cold-air drainage. I offer the meadow in the lower cirque bowl (just above the top of the north gondola) as an example of exclusion of trees by cold-air drainage. Three points favor this hypothesis:

1. Cold air is known to pond in such depressions.
2. Conifers are known to "frost deharden" in spring, so heavy frost might eliminate them; such damage was observed on 3- to 5-year-old seedlings in the spring of 1988. Frost resistance apparently declines from whitebark pine > spruce > fir ≥ lodgepole pine.
3. The cold-air pond is ringed by bands of progressively older trees. Due to every-year frosts, no trees exist on the pond bottom (meadow center). A band of small trees (1 m high and buried by snow in winter) occupy a "shoreline" that hasn't experienced killing frost in 10 years or so, but these are likely to be killed eventually. A higher "shoreline" represents the "highest water" (= deepest ponding) that has occurred in 20 to 40 years; the tops of these trees may have emerged from the cold-air pond and, if so, they may grow crowns with normal tops and frost-pruned bottoms. The largest (mostly beetle-killed) trees occupy an area that is always above the cold-air pond's surface.

Most alternate hypotheses put forward to explain the distribution of trees in this bowl can be dismissed:

1. Avalanche damage seems unlikely, because existing trees show no evidence of snow movement and because alluvial-aeolian soil in the basin bottom lacks avalanche-borne rocks.
2. While colder air ponds in the basin in winter than in the spring, trees are adequately hardened against frost in winter (Tranquillini 1979).
3. Though it is in a depression, most if not all of the meadow site is too well-drained to allow water drowning.
4. Absence of flagging on existing trees discounts the possibility of wind-induced desiccation damage.

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