Discussion

Although causes of change and their effects have been described under each photo pair, discussion of some general cause-effect scenarios that have and are influencing high-elevation landscapes throughout northeastern Oregon is appropriate.

The mini Ice Age subsidence mentioned in connection with the disappearance of the Benson Glacier reflected a global cycle. Regional weather phenomena have been documented through local tree-ring analysis (Keen 1937, Meyers 1934) that shows wet and dry cycles of about 22 years; 11 above normal and 11 below normal, on average. The mid-1890s began a wet period until about 1905, after which a dry cycle began. A full cycle carried on until the deep dry cycle of the mid-1930s. The late 1980s and early 1990s brought a minor drought period with large fires and insect epidemics. A moderately warm, moist condition was experienced through the period of this repeat photography. Because of the no-burn tradition and policy adopted over the past 100 to 125 years, wildfire frequency and intensity in the higher mountains did not necessarily reflect these drought cycles (Agee 1996).

Fire has been a potent force in both grassland and forested areas. Recent catastrophic fires have altered entire landscapes, whereas historical fires were mostly small, cool, and frequent. Native Americans periodically set fires that kept tree seedlings suppressed and favored endemic grasses over shrubs and forbs. With the establishment of the USDA Forest Service in 1906, a policy of fire suppression was instituted that covered even the remote upper elevation forests in northeast Oregon (Beck 1996, Heyerdahl and Agee 1996, U.S. Department of Agriculture 1907). Recent catastrophic fires have been attributed to heavy fuel buildup accruing from long-term fire-suppression policy (McIver 1998).

Insects and diseases are natural forces that cause landscape changes. Outbreaks are frequent disturbance features of most forests, whether the forests are healthy or unhealthy (Burke 1990, Wickman 1992). Insect epidemics may occur more often where fire frequency or natural insect predators become imbalanced. Forest diseases may be less affected by human activities in the high mountain conifer forests than elsewhere (Filip and Schmitt 1990), but presently disease introductions, such as blister rust, are significantly affecting whitebark pine (Linn 1994) and may already be affecting dependent wildlife in the subalpine ecosystem (Kendall and Arno 1990).

Human activities have profoundly affected both forest and nonforest wilderness habitats (Rogers 1996). Domestic livestock grazing was introduced into the mountains of northeastern Oregon in the late 1800s. More and more owners brought their flocks of sheep to feed on the free, abundant native grasses. Early economic returns from these sheep came from their wool, so the goal was rapid increase of herd size. Within 20 years, the wide-scale degradation of the grasslands and forests caused national concern, thereby resulting in the creation of the Forest Reserves. This designation of land set aside entire areas of the most fragile land and protected them from sheep grazing. Effects of unregulated use are still apparent in the higher mountains.

Wildlife in these same areas was also dramatically affected by efforts to protect domestic animals from predators. Extreme efforts were used to rid the mountains of black and grizzly bears, bobcats, cougars, coyotes, lynx, wolverines, and wolves. Trapping of fur-bearing animals was a lucrative livelihood and led to the near demise of marten, mink, and beaver. The marketing and sale of game meat and fish was also profitable until regulations were promulgated, refuges established, and game law enforcement became effective in the 1920s and 1930s.

Early settlers in the valleys commonly lived off the land, which resulted in depletion of elk, mule deer, white-tailed deer, mountain sheep, and pronghorn populations by the start of the 20th century (Irwin and others 1994). Steelhead trout and fall chinook salmon, which spawned in the headwater streams, were also favorite foods of the pioneer.

High mountains provided recreational opportunities for early settlers. During lulls in harvest activities, it was popular for family groups to pack and ride their horses to camp in the high country. These periods were combined with hunting and expeditions to harvest wild berries. After hatchery fish were planted in the high lakes in the early 1900s, fishing also became popular.

Outdoor recreation use seems to have nearly doubled over the past decade according to a report prepared for the Eagle Cap Ranger District (Hall and Shelby 1994). The report estimated that 11,350 groups or a total of 33,400 people visited the Eagle Cap Wilderness in 1993. Of these, almost three-quarters of the groups traveled on foot, and about 70 percent of these were day visitors. Almost half of the livestock users but only 18 percent of the hikers were from northeastern Oregon. Almost 30 percent of hikers came from the Willamette Valley area.

Several problems at these high mountain settings are being addressed administratively (Cole 1982). For example, camping on lake shores is prohibited, and campfires are not allowed close to certain high-elevation lakes. Riparian habitats near lakes and streams are being inventoried and protected. Attempts are underway to restore damaged camp sites at some of the most popular lakes (Cole 1990).

Subalpine fir trees have been encroaching into areas that formerly had little or no fir. The subalpine fir tree invasion has its roots in several historical conditions (Franklin and others 1971). The first is the heavy, depleting grazing that began before the end of the 19th century. This activity reduced herbaceous cover and provided a fertile, competition-free seedbed for tree regeneration. The associated elimination of fine fuel reduced the chances for wildfire that had naturally favored whitebark pine over subalpine fir.

Subalpine fir has thin bark, and the lower branches are in contact with the ground at grass level. The latter feature makes it susceptible to crown fires that destroy even the mature trees. This fir has a small seed with a large wing permitting it to spread long distances. Whitebark pine, on the other hand, has a large, heavy seed and depends on birds and animals for dissemination. Although it has rudimentary seed wings, they remain with the cone at dispersal time.

Subalpine fir and whitebark pine are not regular cone producers. For example, in 1997, cones of whitebark pine were abundant as were Clark's nutcrackers, the principal disseminator of their seed. In 1998, whitebark pine did not produce cones in the Wallowas. In 1999, the cone crop was moderate and spotty, and nutcrackers were common but not abundant. This lack of whitebark pine seeds presents problems because they are important to the wildlife of this high mountain area. They are prized food for squirrels and several species of birds, such as Clark's nutcracker and Stellar's jays. Bears, in turn, rob squirrel and bird caches and rapidly fatten on them just before hibernation. These interactions have been modeled in a study of whitebark pine stand dynamics (Keane and others 1990).

Whitebark pine has high value for watershed protection as well as for food and habitat for wildlife. At elevations above 7,500 feet, whitebark pine is about the only tree that persists under the harsh site conditions on many south-facing slopes. Some limber pine is found on peaks and ridgetops but only in scattered patches.

The loss of several age classes of whitebark pine at upper elevations is a recent and alarming condition, especially in the Wallowas. In several localized areas, this is the result of whitebark pine blister rust, a disease that has been detected here in only the past several decades (Linn 1994). The disease first produces a canker in branches and twigs and may take several years to kill the tree. The alternate host for this disease is gooseberries, several species of which occur throughout the Wallowas. Most common are prickly currant and sticky currant, which are common at 5,000 to 8,000 feet elevations. They spread rapidly through talus and avalanche paths and enter the altitudinal level of whitebark pine. One particular hot spot is the west slope of Brownie Basin and the head of John Henry Wilson Basin where mature and old-growth whitebark pine recently have died.

At lower elevations, regeneration of Engelmann spruce presents a problem by encroaching into wetter areas of meadows. Even lodgepole pine has invaded bare spots in these lower meadows. Subalpine fir becomes the bane of meadows at upper elevations, first by encroaching from surrounding stands along the tree-grass edge and second by regenerating well out into the natural meadow habitat. Probably a combination of factors has permitted this invasion, lack of fire being a chief factor. This invasion has increased and increasingly affects recreational use of the area where meadows provide prime camping sites and sources of forage for pack and saddle stock.

Review

A retake of photographs in the high mountains of northeastern Oregon recorded the effects of a shift from resource exploitation toward one of resource restoration. We tried to recount the disturbance factors that brought about these changes.

Among the changes noted are that woody species are replacing herbaceous plants. Perhaps the most important examples of this are the wholesale encroachment of subalpine fir into areas that formerly had little or no fir and a rapid invasion of meadows by various woody species.

Subalpine fir has been aided in its expansion into new areas by past overgrazing, which created good seedbeds free from competition. Because it is a species susceptible to fire, subalpine fir also has prospered owing to fire-suppression policies. The invasion of woody species into grasslands is evident at Standley (fig. 4) and Mount Nebo (fig. 16) where heavy grazing by domestic sheep around 1900 stripped the ground of native grasses, laying it bare and receptive to the establishment of woody species. Protection from fires that were once deliberately set also has allowed trees to encroach on grasslands.

Diseases are suspected in the loss of whitebark pine. This species is being affected by blister rust, a disease that has been detected here only in the past several decades and that eventually kills the trees. These trees are important for watershed protection as they are often the only trees that persist above 7,500 feet under harsh conditions at sites on south-facing slopes. This tree also provides valuable wildlife food and habitat.

Insect outbreaks have become more frequent in the late 1900s, perhaps encouraged by less frequent burning. Several epidemics of western and mountain pine bark beetle have occurred, particularly in the Francis Lake (fig. 11) and Anthony Lake (fig. 31) areas where many acres of dead whitebark pines stand ghostlike.

Early grazing practices and subsequent fire suppression have allowed invasion of meadows by trees, which affects recreation opportunities. Meadows provide prime camping sites as well as forage for ungulate wildlife and pack and saddle stock (Mount Nebo, fig. 16; Blue Creek Cutoff, fig. 27; and Rock Creek, fig. 33).

Although changes resulting from recreation use are less widespread than changes caused by other disturbance agents, certain desirable locations in the Eagle Cap Wilderness Area have been damaged to the point where administrative action has been taken. Several photo pairs show pristine camping and hiking scenes in the early 1920s in areas that are now closed to camping with restoration efforts underway to reduce the effects left by years of overuse (Chimney Lake, fig. 10; and Upper Lake, fig. 14).

Accelerated erosion continues on former sheep driveways and old bed grounds, but the vegetative ground cover has increased, thereby improving watershed conditions in these high mountains. Anthony Lakes Divide (fig. 31) and Russel Mountain (fig. 30) are examples of good recovery.

Plant diversity has increased noticeably since the early 1900s. Early photos of grazing areas show only grass composition with few, if any, forbs and relatively few shrubs and trees (Flagstaff, fig. 23). This may reflect the fact that sheep selectively grazed forbs and shrubs, that fires were more frequent, which discouraged shrub and forb establishment, or both.

Several picture pairs show gravitational mass wasting of parent material and talus rock disappearance, notably at Sand Pass (fig. 19) and Chaparral Basin (fig. 5). Avalanche chutes and paths showed evidence of successive slides and subsequent tree replacement.

Large stand-replacement fires were common in the past decade in the Wallowas, Elkhorns, and Greenhorns. The Twin Lakes, Sloan Ridge, Tower-Summit, and Fox Point fires altered entire landscapes. Earlier stand-replacement fires were few and confined to sections in the Wallowas. Historical fires were mostly small, cool, and more frequent owing to the fire regime practiced by Native Americans. Of the landscape photos taken before 1925, recent fires showed up in 71 percent of the pictures. Conversely, in the repeat of the late 1990s, only 8 percent of the photos showed evidence of recent fires.

These time-lapse photographs provide a visual record of ecological changes that have occurred on a landscape basis in the high mountains of northeastern Oregon. Without the aid of long-term photography, slow ecological changes are difficult to detect. Old timers reminisce about how the countryside used to be more open, but recollections are not sufficient evidence on which to base management decisions. The foregoing time-lapse landscape photography, however, documents changes that would be difficult to illustrate, even with detailed measurements.

Decisionmakers require an understanding of factors influencing change in patterns of succession in these high mountain areas. With this knowledge, they can plan management activities to best meet the goals of protecting watersheds and providing for increased recreational demands.

Acknowledgments

Special thanks to James McIver, Research Coordinator of the Blue Mountains Natural Resources Institute, for recognizing the importance of landscape analysis based on long-term, time-lapse photography and for facilitating project implementation. We also thank the Wallowa-Whitman National Forest for augmenting the budget shortfall for a full-blown investigation.

Two associates deserving special recognition are Pat Clark, a remote sensing specialist, and Richard McDaniel, a master woodsman and field technician. Other individuals associated with local forest research or administration who provided helpful assistance include Steven Arno, Larry Brandvold, Evelyn Bull, Kendall Clark, David Cole, Charles Ernst, Eric Johnson, George Mead, Catherine Parks, David Powell, Charles Quimby, Tom Quigley, Suzanne Rainville, Craig Schmitt, Norm Cimon, Tom Smith, Lynn Starr, and Dan White.

Information about the dams and reservoirs came from John Falk, Lawrence Del Curto, and Jay Sly. People in the private sector who provided valuable information or materials were Fred Barstad, Aletha Bonebreak, Bill Burkett, Eldon and Marge Deardorff, Gary Dielman, Dale Epling, Jerry and Cathy Gildemeister, Viki Goodner, David Jensen, Randy Jones, Bill and Mary Rautenstrauch, Stephen Rich, and Carol Thelinius. Appreciation is expressed to David Cole, Berta Youtie, Verne Marr, and Ellen Morris Bishop for peer review of the manuscript. Special credit goes to Donna Skovlin for devoted field research assistance and editorial support.

English Equivalents

1 kilometer (km)	= 0.62 mile
1 meter (m)	= 1.09 yards
1 centimeter (cm)	= 0.39 inch
1 millimeter (mm)	= 0.04 inch
1 square kilometer (km^2)	= 0.39 square mile
1 square kilometer (km^2)	= 247.10 acres
1 hectare (ha)	= 2.47 acres
1 liter (l)	= 1.06 quarts (liquid)
1 ton (metric)	= 1.10 tons (English)
1 kilogram (kg)	= 2.21 pounds
1 ton (metric)/hectare	= 0.45 ton (English) per acre

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Appendix—Common and Scientific Names of Species Mentioned

Plants[1]

Trees:

Cottonwood (black)	*Populus trichocarpa* Torr. & Gray
Douglas-fir	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
Grand (white) fir	*Abies grandis* (Dougl.) Lindl.
Limber pine	*Pinus flexilis* James
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Mountain maple, Douglas maple, or vine maple	*Acer glabrum* Tor. ssp. *douglasii* (Hook.) Wesml.
Ponderosa pine	*Pinus ponderosa* Dougl. ex Loud.
Poplar	*Populus* spp.
Prostrate juniper	*Juniperus communis* L. var. Montana Ait.
Sitka alder	*Alnus sinuata* (Regel) Rydb.
Subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
Western larch	*Larix occidentalis* Nutt.
Whitebark pine	*Pinus albicaulis* Engelm.
Willow	*Salix* spp.

Shrubs:

Bush cinquefoil	*Potentilla fruticosa* L.
Gooseberry	*Ribes* spp.
Grouse wortleberry	*Vassinium scoparium* Leib.
Mountain big sagebrush	*Artemisia tridentata vaseyana* (Rydb.) Beetle
Mountain heather	*Cassiope mertensiana* var. *gracilis* (Bong.) G. Don
Mountain-mahogany	*Cercocarpus ledifolius* Nutt. in T. G.
Phlox	*Phlox* spp.
Prickly currant	*Ribes lacustre* Pursh.
Scoulers willow	*Salix scouleriana* Barratt
Snowbush (sticky) ceanothus	*Ceanothus velutinus* Dougl.
Sticky currant	*Ribes viscosissimum* Pursh.
Willow	*Salix* spp.

Grasses:

Bluebunch wheatgrass	*Agropyron spicatum* (Pursh) Scribn. & Sm.
Bottlebrush squirreltail	*Sitanion hystrix* (Nutt.) J. G. Sm.
California oatgrass	*Danthonia californica* Boland.
Columbia needlegrass	*Stipa occidentalis* Thurb. ex Wats. var. *minor* (Vasey) C.L. Hitchc.

[1] Nomenclature for plants, forbs, shrubs, and trees follows Garrison and others (1976).

Green fescue	*Festuca viridula* Vasey
Kentucky bluegrass	*Poa pratensis* spp.
Mountain brome	*Bromus marginatus* Desf.
Mountain oatgrass	*Danthonia intermedia* Vasey
Pinegrass	*Calamagrostis rubescens* Buckl.
Red fescue	*Festuca rubra* L.
Thin bentgrass	*Agrostis variabili* Rydb.
Thin grass	*Agrostis diegoensis* Vasey
Timothy	*Phelum pratense* spp.
Tufted hairgrass	*Deschampsia caespitosa* (L.) Beauv.
Western needlegrass	*Stipa occidentalis* Thurb. ex Wats.
Western fescue	*Festuca occidentalis* Walt.

Grasslike:

Baltic rush	*Juncus balticus* Willd.
Beaked sedge	*Carex rostrata* Boott.
Elk sedge	*Carex Geyeri* Boott.
Hood sedge	*Carex Hoodii* Boott.
Nebraska sedge	*Carex nebraskensis* Dewey
Parry's rush	*Juncus Parryi* Engelm.
Rush	*Juncus* spp.
Sedge	*Carex* spp.
Water sedge	*Carex aguatilis* Wahl.
Wire rush	*Juncus filiformis* L.

Forbs:

Biscuitroot	*Lomatium dissectum* var. *multifidum* (Nutt.) Math. & Const.
Buckwheat	*Eriogonum* spp.
False horsemint	*Prunella* spp.
Gland cinquefoil	*Potentilla glandulosa* Lindl.
Goldenrod	*Solidago missouriensis* Nutt.
Gooseberry	*Ribes* spp.
Indian paintbrush	*Castilleja* spp.
Owl's clover	*Orthocarpus* spp.
Penstemon	*Penstemon* spp. Mitch.
Pokeweed fleeceflower	*Polygonum phytolaccaefolium* Meisn. ex Small
Pussytoes	*Antennaria* spp.
Strawberry	*Frageria* spp.
Tailcup lupine	*Lupinus caudatus* Kell.
Tarweed, cluster	*Madia glomerata* Hook.
Twin flower	*Linnaea borealis* L. spp. *Longiflora* (Torr.) Hulten
Umber (brown) pussytoes	*Antenrarnia umbrinella* Rydb.
Western coneflower	*Rudbekia occidentalis* Nutt.
Yarrow	*Achillea Millefolium* var. *lanulosa* Piper

Animals

Mammals:[2]

American marten	*Martes americana* (Rhoads) (Turton)
Beaver	*Castor canadensis* var. *pacificus* Rhoads (Schreber)
Black bear	*Ursus americanus* Pallas Kuhl
Bobcat	*Lynx rufus* Rafinesque
Cougar (mountain lion)	*Felis concolor* (L.)
Coyote	*Canis latrans* Say
Elk	*Cervus elaphus* (L.)
Fisher	*Mustela pennanti* (Rhoads) (Erxleben)
Grey wolf	*Canis lupus* (L.)
Grizzly bear	*Ursus arctos* (L.)
Lynx	*Lynx lynx* Kerr
Mink	*Mustela vison* Schreber
Mountain (bighorn) sheep	*Ovis canadensis cadensis* Shaw
Mule deer	*Odocoileus hemionus* (Rafinesque)
Pronghorn	*Antilocarpa americana* (Ord)
Squirrel	*Tamiasciurus* spp.
White-tailed deer	*Odocoileus virginianus ochrourus* (Zimmermann)
Wolverine	*Gulo gulo* (L.)

Birds:[3]

Clark's nutcracker	*Nucifraga columbiana* (Wilson.)
Stellar's jay	*Cyanocitta stelleri* (Gnelin)

Fish:[4]

Salmon	*Salmonids*
Chinook	*Oncorhynchus tschawytscha* (Walbaum)
Steelhead trout (summer run)	*Salmo gairdneri* (Richardson)

Insects:[5]

Douglas-fir bark beetle	*Dendroctonus pseudotsugae* (Hopkins)
Mountain-pine bark beetle	*Dendroctonus ponderosae* (Hopkins)
Western pine bark beetle	*Dendroctonus brevicomis* (LeConte)

Diseases:[6]

Blister rust	*Cronartium ribicola* Fisch ex Rabh

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[2] Nomenclature for mammals follows Hall (1981) and Jones and others (1992).

[3] Nomenclature for birds follows that of the American Ornithologists Union (1983).

[4] Nomenclature for fish follows that of the American Fisheries Society (1970).

[5] Nomenclature for insects follows Furniss and Carolin (1977).

[6] Nomenclature for diseases follows Hedwigia (1872), and Torry Botanical Club Bulletin (1895), respectively.

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