WORKSHOP PRECEEDINGS:

RESEARCH & MANAGEMENT IN WHITEBARK PINE ECOSYSTEMS

May 3, 1994 - Glacier National Park

Preceedings Compilers:

* Katherine C. Kendall
* Brenda Coen

Workshop Sponsors:

* National Biological Survey - Glacier Field Station
* Glacier National Park
* Flathead National Forest
* Intermountain Research Station
* Society of American Foresters

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Workshop Organizers:

- National Biological Survey - Glacier Field Station
  - Katherine C. Kendall
  - Brenda Coen
- Intermountain Research Station
  - Bob Keane
- Flathead National Forest
  - Brian Donner
  - Ken Brewer

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The purpose of this workshop is to exchange information on on-going and soon-to-be-initiated whitebark pine research and management projects. By doing so we hope to encourage future work on this valuable species. We also hope to promote the use of consistent methods for evaluation and investigation of whitebark pine, and to provide avenues of collaboration.

Speakers will present information on a variety of topics related to whitebark pine management and research. Featured presentation topics include anthropomorphic utilization of whitebark pine forests, whitebark pine natural regeneration, blister rust and the decline of whitebark pine, blister rust resistance studies, ecological mapping of the species, restoration and management projects, and survey/monitoring techniques. Information gained from these presentations may hopefully be used in the planning of future projects for the conservation of whitebark pine.

This is the eighth in a series of workshops and symposia concerning whitebark pine ecology and management. The following is a list of these events:

A Mini-Workshop: Whitebark pine -- its significance, ecology and management. Bozeman, MT, Feb. 24, 1987.

Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource. Bozeman, MT, March 29-31, 1989.

Whitebark Pine Workshop. Glacier National Park, July 17, 1989.

Whitebark Pine Workshop. Columbia Falls, MT, Oct. 10-11, 1991.

Whitebark Pine -- New Management Perspectives in the Greater Yellowstone Area. Bozeman, MT, Jan. 22, 1992.

International Workshop on Subalpine Stone Pines and Their Environments -- The Status of Our Knowledge. St. Moritz, Switzerland, Sept. 5-12, 1992.

Management of Whitebark Pine Ecosystems -- An International and Regional Perspective. Bozeman, MT, April 23, 1993.

Research and Management in Whitebark Pine Ecosystems. Glacier National Park, West Glacier, MT, May 3, 1994.

The following is a schedule of presentations and a compilation of the extended abstracts and summaries for all presentations from this workshop. A list of all participants and their addresses is also included. We hope this workshop will benefit you and your efforts to conserve this important high-elevation species.

ORGANIZING COMMITTEE:

Chair: Kate Kendall, National Biological Survey, Glacier National Park
Bryan Donner, Glacier View RD, Flathead National Forest
Bob Keane, Intermountain Research Station
Ken Brewer, Hungry Horse RD, Flathead National
Ward McCaughey, Intermountain Research Station

Special Thanks to Brenda Coen for compilation and editing of abstracts

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RESEARCH AND MANAGEMENT IN WHITEBARK PINE ECOSYSTEMS
Glacier National Park -- May 3, 1994

Morning Session -- Research Projects

Time	Presentation	Author
	MODERATOR: Kate Kendall, GNP-NBS, USDI	
7:00	Poster Setup, Registration	None
8:30	Welcome, Workshop objectives	Pete Peterson
8:35	Why Have the White Bark Pine Stopped Producing Cones?	Bud Cheff
9:00	High-Country Archeology in the Bitterroot Mountains	Ben Munger
9:20	Landscape Processes Affectign the Decline of Whitebark Pine (*Pinus albicaulis*) in the Bob Marshall Wilderness Complex, Montana, USA	Robert E. Keane
9:40	Long-Term Dynamics of Whitebark Pine: Tree-Ring Studies in Central Idaho	Dana Perkins
10:00	Break	
	MODERATOR: Dick Krebill, INT Station, USDA FS	
10:20	Whitebark Pine Regeneration Processes in the Sundance Burn of Idaho	Diana F. Tomback
10:40	Susceptibility of Whitebark Pine Seedlings Artificially Inoculated with Blister Rust	Ray J. Hoff
11:00	Silvicultural Treatments and Whitebark Pine Plantation and Regeneration Trails Results	Ward McCaughey
11:20	Ecological Mapping of Whitebark Pine in Glacier National Park	Kate C.Kendall
11:40	OPEN	
12:00	LUNCH -- Catered in the Community Room of Conference Center	

WHITEBARK WORKSHOP
Glacier National Park -- May 3, 1994

Afternoon Session -- Management Projects and Perspectives

Time	Presentation	Author
	MODERATOR: Deb Manley, Glacier View District Ranger, USDA, FS	
1:00	Whitebark Pine and Ecosystem Management: An Ecological Perspective	Wendel Hann
1:20	The Application of Aerial Sketchmapping Surveys as an Inventory Tool at the Landscape Level in Whitebark Pine Ecosystems	Tim McConnell
1:40	Whitebark Pine Information Survey Results, USDA Forest Service, Region 6	Joe Linn
2:00	Precommercial Thinning to Favor Whitebark Pine on the Twisp Ranger District, Okanogan National Forest	John Rohrer
2:20	Madison Range Ecosystem Management Project	Alan Vandiver
3:00	BREAK	
	MODERATOR: Wendel Hann, Regional Office, USDA FS	
3:20	Ecosystem Monitoring and Sampling in Whitebark Pine Ecosystems	James P. Menakis
3:40	Whitebark Pine Restoration in Wilderness	Greg A. Warren
4:00	Whitebark Pine Cone Development and Collections in 1993	Lars K. Halstrom
4:20	PANEL DISCUSSION Chaired by: Wendel Hann, Dick Krebill, Kate Kendall Topics: Whitebark Pine Management Symposium Whitebark Pine Monitoring Network Sampling Techniques	

POSTER SESSION: Ward McCaughey, INT, USDA FS -- Host

5:00	Poster Session with Hors d'Oeuvres / Social	
5:00	Tour of GNP Native Plant Nursery	Dale Wick Tara Luna
6:30	Catered Dinner	All

WHY HAVE THE WHITEBARK PINE STOPPED PRODUCING CONES?

Presented by Bud Cheff

BUD CHEFF, 4003 Eagle Pass Trail, Charlo, MT 59824

ABSTRACT

I first saw the White Bark Pine nut in the year of 1924 when I was invited to go on my first pack trip with a group of full blooded Indians. We went into the wildest area of the Mission Mountains.

The following year, in 1925, I was again invited to go with these people and some others, into the Bob Marshall. At that time the area was just called the South Fork of the Flathead. I went with these Indians every year until I got married. Each year we would gather a supply of pine nuts. For my friend Bill Conko and me, this was a fun time. And, I think, fun for all, as everyone in the group went along to pick the cones. A favorite spot was Elk Divide, just southwest of Elk Lake, although we picked them in several different places. The more active people would climb up into the trees and shake and knock the cones off with sticks. Some would use long poles to knock them off with. It seemed like everyone was laughing and having a big time. The older women would sack them into burlap bags. The trees used to produce in abundance, and even the small trees would be bent over with the heavy cones.

Before hibernation time the grizzly bear fed on these nuts nearly 100% when the trees were producing good. The black bear also fed on them, but usually in different areas. The sknalk, (the Indian name for the Canadian jay, or nutcracker) gathered by the hundreds or thousands to feed on them, as did the blue grouse, which were in abundance then. The pine squirrels were running back and forth carrying these nuts, storing them for the winter.

Along about the late 30's I noticed that the trees were not producing as many nuts. The nuts were getting smaller, and many of them were deformed. I have always felt that there had to be something in our air to cause the problem. there are other plants that are also having problems.

Notes

HIGH-COUNTRY ARCHEOLOGY IN THE BITTERROOT MOUNTAINS

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ABSTRACT

In this paper I will cover archeological evidence of Whitebark pine nuts as a native food source found at timberline in Bitterroot Mountains of western Montana. I suggest that along with meat from hunting, Whitebark pine nuts were an important timberline food resource for Native Americans in the Northern Rocky Mountains. Further research needs to focus on how this resource resource was exploited. Archeological evidence from the Bitterroot Mountains suggests that permanent camps were not present at or above timberline. Permanent late summer camps may be located at lower elevations to equally access salmonid, ungulate, and pine nut resources. It is suggested that the Bitterroot Mountains were occupied on temporary hunting and gathering trips by families who entered from either the Montana or Idaho side of the Divide. Whitebark pine nuts were collected and returned to base camps at lower elevations (6,000 ft. asl). I will also examine the changes in the United States Forest Service regarding ecosystems management and archeology's (heritage resource management's) role in this new management arrangement. I suggest that archeologists have an important role in understanding pre-Euroupean ecosystems. Ground stone artifacts which would have been used for processing pulpy nut foods like Whitebark pine nuts have been recovered from the Bitterroot Mountains at timberline and at hypothesised summer base camps in the Highland Mountains of Montana. Archeological evidence of nut processing may help reconstruct past environments and hopefully place humans more firmly, besides the acknowledged use of fire and hunting, in the role of active agents shaping the Rocky Mountain ecosystem.

THE BITTERROOT RANGE - THE GREAT BURN AREA

The Bitterroot Range divides Montana and Idaho and the Clark Fork and Clearwater drainages. The Great Burn area (Figure 1), where I did my research, has an unusually high density of archeological sites between 6,000 ft. and 8,000 ft. at timberline (McLeod and Melton 1986). The project area is within and above the upper timberline, though it is considered a false alpine because of the intense 1910 forest fires and overgrazing by sheep until the 1930's. As a consequence, the study area has excellent ground visibility with little or no ground vegetation (beargrass and Mountain Heather) in the northern half. Dominant tree species includes clumps of alpine fir, Englemann spruce, and Whitebark pine, but a thick forest of Lodgepole pine covers the lower elevations of the southern half the study area. The geology of the area is complex: the Lolo Batholith dominates the southern portion of the study area and Precambrian Belt Rocks the northern half. Wedged between the two is the Rhodes Peak Caldera, responsible for vitrophyre quarries in the area. Glacially carved valleys curve into the mountain peaks with

vertical cliff faces of several hundred feet in the Rhodes Peak area and upper Cache Creek drainage.

I conducted archeological survey for two and a half summer seasons in the Great Burn covering twenty miles of the Bitterroot Range from Kid Lake to Granite Pass. The archeological survey was sponsored by the Lolo National Forest as part of the Limits of Acceptable Change process whereby baseline data is gathered to assess potential impacts to the area if it were designated as a wilderness with a capital "W".

WHITEBARK PINE - A NATIVE FOOD SOURCE IN THE HIGH-COUNTRY

After two seasons of archeological survey the collected archeological data suggested: (1) archeological sites clustered in the more rugged, high elevation areas, and (2) there was the appearance of abraded river cobbles in sites in the high elevation areas. At this point in the process I met Steve Arno and Robert Keane who are research foresters for the Forest Service Fire Science Lab in Missoula. Arno and Keane where studying Whitebark pine (Pinus albicaulus) in the Great Burn. They pointed to all the dead, white, skeletons of "ghost" snags in the high-country of the Great Burn and said the area had been a climax Whitebark pine forest only 200 years ago. The introduction of the mountain pine beetle, blister rust, and the suppression of low intensity fires, that would have helped to kill competitors, seemed to be the causes for the loss of Whitebark pine stands (Arno 1986).

Arno also suggested that Whitebark pine was an important food source for Grizzly Bear, Red Squirrel, and the Clarks Nutcracker and he noted that it may have been an important food source for Native Americans using the high-country. Arno pointed to a ethnographic source in a article by Bud Cheff (Cheff 1984), an early resident in the Mission Valley, who collected Whitebark pine nuts and cones with Flathead Indians in the Mission Mountains. Subsequent review of regional ethnographies revealed that Steward (1938) documented use of Whitebark pine by the northern Shoshone, Teit (1928) documented use with the Pend'd Oreille, and Turney-High (1937) with the Flathead. Most importantly, Alan Marsall (1977) noted the use of Whitebark pine nuts among the Nez Perce, during hunting and collecting trips into the Clearwater and Bitterroot Mountains. I will return to Marshall later who's model for Nez Perce settlement patterns was important to explaining the patterns I observed in the Great Burn.

PREVIOUS RESEARCH - HUNTING AND CHRONOLOGY

Archeological research had always focused on hunting strategies in the mountains of Western Montana to explain high-country archeological sites. Excavations at Big Creek Lake (Fredlund 1979) revealed a mountain sheep hunting camp, Bonnie Hogan's (1974) thesis discussed game trapping the Bitterroot Mountains, and archeological survey in the Bitterroot Mountains by Fredlund and Lacomb (1971) spawned the idea of saddle drives for mountain sheep, deer, and elk. All these

interpretations were probably correct, but it seemed to me that something was missing from the picture of the past in the high-country of the Bitterroot Mountains.

Chronologically, my research and Fredlund (1979) suggests that the timberline area was first used in the Middle Middle Prehistoric Period (2,500 B.C.- 1500 B.C.), a subdivision of the the Middle Prehistoric Period. Along the Snake and Clearwater River this period is characterized by population aggregations in pit house villages, with an intensification of the use of root crops and river clams. On the Bitterroot Divide I collected a small sample (20) of projectile points from the surface of the survey area. Based on comparative typology I identified two McKean complex points and seven Elko corner-notched points. The remainder of the point styles are affiliated with either the Desert or Plains side-notched type dating to the Late Prehistoric Period (A.D. 500-1700). I suggest that the high-altitude country in what is now western Montana may have seen its first systematic habitation during the Middle Period. This view conflicts with Frison (1978), Bender and Wright (1988), and Davis (1993) who find Late Paleo Indian occupation of the mountain-foothill zone in the Northern and Middle Rocky Mountains. Frison (1978) points out that the Late Paleo Indian people were foragers exploiting the diverse economy of the mountains. Further research in western Montana high-country may also prove this to be true. I am not suggesting that the Bitterroot Mountains were a refuge for Archaic foragers retreating from the Northern Plains or Great Basin/Plateau during the Altithermal: there is not enough data to address this question.

The study area is in a chronological no-mans-land and I used both established point style sequence from the Northern Plains (Frison 1978) and Reeves (1974) and from the Columbia Plateau (Leonhardy and Rice 1970). Significantly, the paleoclimatic record from Lost Trail Pass (Mehringer 1985) suggests that Whitebark pine returned to the high-country of the Bitterroots at the same time as the first human use - tentatively assigned with the McKean points.

CURRENT FOCUS - WHAT ABOUT THE ANTHROPOLOGY?

At this point I got into graduate school and one of my professors said," well this is interesting about the native use of this Whitebark pine resource, but what about the anthropology?" After reviewing literature on mountain archeology in the West I came across an article by Bender and Wright (1988). They suggested, that in the high-country of the Teton Mountains in Wyoming, a complete example of broad-spectrum adaptation was archeological visible. To explain the observed patterning of archeological sites they used Binford's (1980) collector model. The model uses two camps: one as a residential base camp, and a secondary or field camp when hunters/collectors are too far away from the residential camp to return for the night. Considering mountain topography, residential base camps could be any where from four to six miles from the field camps. The use of this two camp system is referred to as logistic organization and is an efficient strategy when

hunting/collecting a broad-spectrum of mountain resources. Other site types in the collector model includes special use sites like kill sites, information gathering lookout sites, caches of food or other resources, and possibly lithic quarries. In contrast, the forager model (Binford 1980) contains no secondary field camps. Hunters and gathers work from a main residential camp and return to that camp each night. Residential bases are moved frequently to access game populations, referred to as a "mapping on" strategy. This strategy focuses on singular resources, like for example, only ungulate hunting.

Basically the difference between forager and collector strategies is a contrast in adaptive strategies. Bettinger and Baumhoff (1982) point out that Numic People, used a processor or collector strategy rather than a foraging strategy. Utilizing a broad-spectrum diet, they were able to spread from a core in the Desert West to throughout the Intermountain West, displacing existing groups who remained focused on singular resources. The concept of broad-spectrum adaptation in hunter-gatherer studies implies that humans are intensifying their use of the land and its resources. In this case I assume that the use of the mountains of Western Montana intensified over time.

I chose to use the collector model in the Bitterroot Range because I needed a yardstick to measure the archeological data. I also had an idea that the sites I had recorded in the study area above timberline could not be residential base camps. All of the sites lacked what Thomas (1983) refers to as characteristic of residential sites in the high-country of the Great Basin," substantial houses, milling stones, female specific fabrication items, domestic evidence and any evidence of child rearing". My inclination was that the sites above timberline were field camps and represented short-term occupation of the Bitterroot Divide. I defined the assemblage level characteristics of the sites after Thomas (1983); an excellent reference for non-site settlement studies in the Intermountain West. The soil loss in the survey area, from overgrazing, fire, and the loss of overstory, allowed for excellent ground visibility in the majority of the recorded archeological sites.

The archeological survey I conducted over two in half years revealed 27 archeological sites. In my (Thomas 1983) definition there were 4 field camps, 10 stations, 11 special use sites, and 1 lithic quarry. At each site I measured total lithic debris, non-waste artifacts, and area. No sites were large or diverse enough to classify as residential base camps in the study area. Specifically the field camps lacked fire affected rock, burnt bone, and permanent site "furniture" like stone circles, hearths, or large metate like grinding stones. Bettinger (1993) has documented well defined alpine villages in the White Mountains of Eastern California with extensive ground stone tools. In the Highland Mountains of Montana, Davis (1993) has reported on a residential base camp with extensive ground stone tools and a high diversity of chipped stone tools. Along the Lochsa River west of the Bitterroot Divide Sappington and Carley (1989) describe a residential base camp which is defined by abundance of ground stone, fire hearths,

and a high diversity of chip stone artifacts. For a more extensive discussion of the archeological difference between residential base camps and field camps on the Bitterroot Divide see Munger (1993).

The abraded river cobbles discovered during the field survey occurred in field camps and in special-use sites. I suggest that the abraded cobbles were used to get the Whitebark pine nuts from the cone, then crack the nuts open. It could be considered "snacking" food (Binford 1980), while the main focus would have been hunting. It is also suggested that Whitebark pine nuts were collected and returned to a residential base camp at lower elevations. This is why we need to closely examine base camps during excavation - is there evidence of processing a resource like the pine nut in the form of ground stone or roasting or parching pits?

MOUNTAIN SETTLEMENT PATTERNS - WHERE ARE THE RESIDENTIAL BASE CAMPS?

Mountain settlement studies in the 1980's suggest that residential base camps were not located in alpine zones of the Northern Rocky Mountains. Archeologist Steve Hackenburger (1988) in his cultural ecology settlement pattern study of the Salmon River suggests that base camps were positioned to take advantage of ungulates, root crops, pine nuts, and salmonids. Alan Marshall (1977), an ethnographer, demonstrates that the location of late summer main residential camps are between 3,000 ft. and 6,000 ft.. Hunting and gathering parties would leave residential base camps then enter the high-country on 7 to 8 day hunting trips using major ridge lines as travel routes. On the main ridge line the hunters/collectors would use field camps each night before returning to the main residential base camp.

My explanation of the available archeological data is that prehistoric peoples did not make residential shifts to the alpine zone during the summer/fall. Sites on the Bitterroot Divide between 6,000 ft. and 8,000 ft. lack residential base camps which I suggest are located at a lower elevation between 3,000 ft. and 6,000 ft.. I suspect the upper Kelly Creek on the Clearwater side of the Bitterroot Divide and upper Fish Creek on the Clark Fork side as potential residential locations. McLeod (1993) recently tested a possible residential base camp on a alluvial terrace above the confluence of Cache Creek and Surveyor Creek, which is in the upper Fish Creek drainage.

The alpine zone of the Bitterroots is a narrow uplands and in the past was also a climax Whitebark pine forest. This narrow upland differs from the broad high-country plateaus of the Middle Rocky Mountains. If I expanded the study area to include the mid-elevation drainages I would find the archeological evidence of broad-spectrum adaptation and the collector model proposed in the Middle Rocky Mountains. The difference appears to be that residential base camps in the Northern Rocky Mountains are located at mid-elevation levels to equally access upland game, vegetal resources, and fisheries.

MONTANE FORAGERS - THE NORTHERN ROCKY MOUNTAINS

The prehistoric use of the mountains was explained in terms of task specific use in the 1970's, a term reflecting anthropological thinking at the time. I propose that we refer to the prehistoric use of the mountains as montane foraging, a term borrowed from Mark Aldenderfer (in press) where hunting, collecting, and quarrying were equally part of the prehistoric system. For the Northern Rocky Mountains the term montane forager should convey the generalist broad-spectrum strategy used by Frison (1978) to describe an alternate adaptive strategy to Northern Plains bison hunting. Archeologists which favor "In-situ" development for the Northern Rocky Mountains like Swanson (1966), Roll (1982), Flint (1982), and Loendorf (1973) all discuss this mountain adapted culture which can be labeled montane foragers.

ECOSYSTEM MANAGEMENT - HOPEFULLY INTEGRATIVE RESEARCH

Integrative research and management are currently hot topics in the United States Forest Service. The new management thrust is ecosystem management which seeks to manage the total ecosystem instead of bits and pieces of the system. Archeological information is essential for this type of integrative management. We have the potential of providing information on prehistoric land-use that is now unknown and would complete the picture of a functioning pre-Euroamerican ecosystem. Barrett and Arno's (1982) article titled Indian Fires as an Ecological Influence in the Northern Rockies provided the basic understanding of how an ecosystem was manipulated by native peoples. Ideally we need to work from a residential base camp like Steel's Pass, using expertise from research foresters, biologists, paleobotanists, geologists, and archeologists. Modeling change over time in the abundance and distribution of game species and seed or root producing plants, whose existence could be tested archeologically at the site, would greatly help our understanding of how montane foragers changed exploitive strategies. An ecosystem with human ecology or culture as a driving force would provide a clearer understanding of pre-European North America and allow us to ask questions that we don't know how to ask. For example, what where the risks associated with the collection of Whitebark pine nuts? Is there another resource that would require less risk and compete with Whitebark pine nuts? What are the extensive ground stone tools at Steel's Pass Campsite used for: processing seeds, roots, or meat? We can begin to understand what resources were available through time for montane foragers in mountain ecosystems and examine what resource use intensified over time.

CONCLUSION - WE NEED TO INVENTORY!

From my experience in the Bitterroot Mountains, which began at the basic inventory level in the Great Burn of western Montana, to a stab at integrative research, we may now look differently at what resources were important to montane foragers. Whitebark pine nuts now seem like an important food source in the high-country. I also have suggested the use of the mountains in western Montana be understood in terms of montane foraging under the larger umbrella of

a broad-spectrum adaptation model. Further research needs to be accomplished in the basic inventory of large areas like Wilderness areas and in excavation of important mountain base camps like Steel's Pass Campsite. Most importantly we need to know how prehistoric peoples used the mountain ecosystem and place humans firmly in the functioning pre-European ecosystem.

Notes

LANDSCAPE PROCESSES AFFECTING THE DECLINE OF WHITEBARK PINE (*Pinus albicaulis*) IN THE BOB MARSHALL WILDERNESS COMPLEX, MONTANA, USA

Robert E. Keane[1] and Penelope Morgan[2]

INTRODUCTION

Whitebark pine (*Pinus albicaulis*) is declining in large areas of the northern Rocky Mountains because of several ecological processes interacting at different spatial and temporal scales (Ciesla and Furniss 1986, Keane and Arno 1993, Arno 1986, Kendall and Arno 1990). The successional replacement of whitebark pine by subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) is a process that, prior to 1930, was usually interrupted by naturally occurring fires. However, 60 years of fire exclusion policies combined with insect and disease epidemics have allowed fir and spruce to become dominant in many forests historically dominated by whitebark pine (Arno 1986). Blister rust (*Cronartium ribicola*), an exotic disease from Europe, has killed extensive stands of whitebark pine in northwestern Montana and northern Idaho (Arno and Hoff 1989, Keane and Arno 1993, Hoff et al 1980). The interaction of these processes has accelerated the decline of the species.

This paper will investigate the complex interaction among landscape processes affecting whitebark pine dynamics in the Bob Marshall Wilderness Complex of northwestern Montana. Processes to be examined in this paper include weather, fire, pathogens and plant succession.

BACKGROUND

The Bob Marshall Wilderness Complex (BMWC) is a remote 500,000 hectare preserve consisting of mountainous terrain dissected by three major river drainages (Figure 1). The Continental Divide is a high mountain barrier that transects the wilderness creating a unique blend of climates and plant communities. The climate

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west of the divide is modified maritime with cool, wet winters and short, warm, dry summers. East-side climates are continental with widely fluctuating winter temperatures and warm dry summers. Strong winds are common on the east side of the Continental Divide. (Soil Conservation Service 1981).

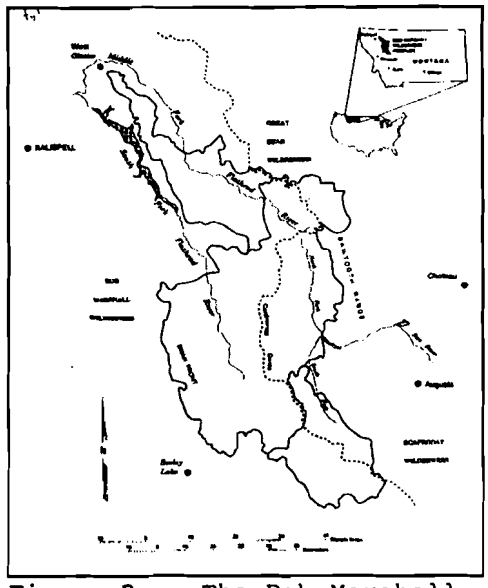

Figure 2 -- The Bob Marshall Wilderness Complex (BMWC) in west-central Montana, USA includes over 500,000 hectares.

Whitebark pine is usually a major seral species at elevations above 1830 meters within the study area. On this basis, it has the potential to dominate 30-40 percent of the landscape within the BMWC (Bain 1990). In the absence of disturbance, whitebark pine is eventually replaced by the more shade-tolerant subalpine fir and Engelmann spruce in most of the area, but it can form nearly pure climax stands on some high, droughty ridgetops (Pfister et al 1977).

Fires are a common disturbance process on the BMWC landscape. Ayres (1901) estimated 20 to 40 percent of BMWC's whitebark pine forests burned during 1860 to 1900. Large, stand-replacement fires are typical in the study area, especially in the whitebark pine zone (Losensky 1990). The great seed dispersal distances provided by the nutcracker allow whitebark pine a competitive advantage in colonizing the large areas burned by these fires (Tomback et al. 1990). Also, Clark's nutcrackers prefer open, burned areas to cache whitebark pine seeds (Tomback et al. 1990). Some whitebark pine stands in higher and drier areas contain evidence of less severe, more frequent surface fires (Gabriel 1976). These fires tend to kill most competing conifer species thereby favoring the somewhat fire-resistant whitebark pine (Arno 1986). The current prescribed natural fire program for the study area allows fire to play its natural role in maintaining the BMWC ecosystem integrity (USDA Forest Service 1990). However, historical fire management policies from the 1930's to 1960's provided for exclusion of fire from the BMWC landscape.

The exotic white pine blister rust is killing many whitebark pine trees in the BMWC (Keane and Morgan 1993, Keane et al. 1993). This disease requires an alternate host of gooseberry or currant (*Ribes* spp.) shrubs to complete its life cycle (Colley 1918, McDonald et al. 1981). Basidiospore transport, germination and subsequent stomatal penetration have the most exacting environmental conditions in the entire life cycle of the rust.

METHODS

The BMWC was divided into five geographic zones for comparing landscape processes to whitebark pine decline (Figure 2). These zones were delineated based

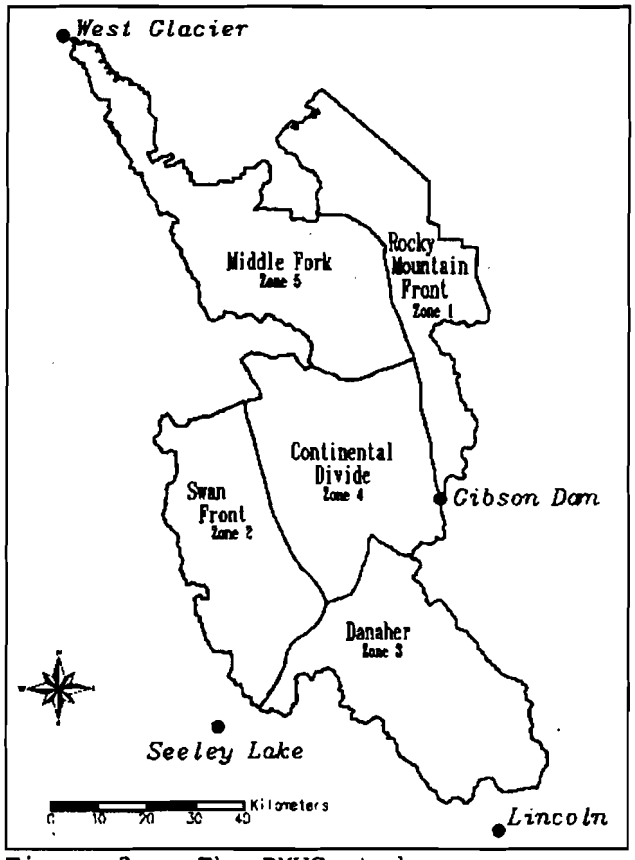

Figure 3 -- The BMWC study area was divided into 5 zones for analysis and each zone was assigned a NWS weather station.

accuracy of 60% to 80% (Keane et al. 1993) (Table 1). The TM scene did not include the northern and southern portions of the BMWC so these areas were eliminated from this analysis. These data represent the current state of vegetation on the BMWC resulting from the successional process.

Pathogens

In addition, Keane et al. (1993) used field data, TM imagery and the classified cover type map to classify forest condition of their analysis area. Three forest condition classes were used to on similarity in vegetation, topography, weather and hydrology (Keane et al. 1993, Arno 1979). Quantification of important landscape processes was accomplished using GRASS spatial software (USA CERL 1990) from the data sources discussed below. This study is a general investigation into the causal mechanisms of whitebark pine decline.

Succession

The spatial extent of successional communities on the BMWC subalpine landscape was taken from a classification of cover types from satellite imagery and an intensive ecological inventory of BMWC whitebark pine forests (Keane and Morgan 1993, Keane et al. 1993). A 1990 late summer Thematic Mapper (TM) satellite scene was classified into 15 high elevation cover types to an

Table 1 -- Land area and percent by cover type in analysis area of BMWC (area covered by TM scene that > 1830 m elevation).

Cover Type Num	Name*	BMWC Land Area Hectares	(%)
1	PIAL-ABLA-PIEN	136,930	44.0
2	ABLA-PIEN-PIAL	18,983	6.1
3	PIAL-PICO-ABLA	16,910	5.4
4	ABLA-PIAL-PICO	62	0.1
5	PIAL-PICO	18,899	6.1
6	PIAL-LALY-ABLA	226	0.1
7	PIAL-LALY	4,067	1.3
8	ABLA-PIAL-LALY	738	0.1
9	PICO-ABLA	3,497	1.1
10	ABLA-PIEN	17,927	5.8
11	PICO	6,796	2.2
12	Shrubs	28,382	9.1
13	Herbs	20,668	6.7
14	Rock, Soil	37,173	11.9
Totals		311,258	100.0

*PIAL- Pinus albicaulis, ABLA - Abies lasiocarpa, PIEN - Picea engelmannii, PICO - Pinus contorta, LALY - Larix lyallii

Table 2 -- Characteristics and extent of forest TM classified forest condition classes in BMWC analysis area.

Descriptive Element	Forest Condition Class Low	Moderate	High
	Stand Characteristic		
Rust-infected trees	0 to 50%	51% to 90%	91% to 100%
Crown foliage killed	0 to 10%	11% to 40%	41% to 100%
Snags/hectare	0 to 10	10 to 50	>50
	Landscape composition		
Land area (ha)	75,682	77,076	44,056
Land area (%)	39.0	39.0	22.0

determine the level of mortality across the BMWC forested upper subalpine areas at approximately 75% accuracy (Table 2). This classification does not differentiate between the causes of mortality, but Keane et al. (1993) identified blister rust as the predominant mortality agent.

Climate - Interaction of Topography and Weather

Elevation, aspect and slope of all lands within BMWC boundaries were computed from USGS digital elevation models (DEM's) using the GRASS spatial software (USA CERL 1990). Allareas below 1830 m in elevation were excluded from this analysis because intensive field observations indicate whitebark pine is seldom a major forest component below this elevation in the BMWC (Arno and Hoff 1989, Bain 1989, Pfister et al. 1977, Keane et al. 1993). Then, BMWC landscape topography was classified into 60 classes based on all combinations of 5 elevation classes, 4 aspect classes and 3 slope classes (Table 3). Each combination was then mapped on the BMWC landscape into a topographic layer with the GRASS spatial software. These data were used with the weather data to quantify the process of climate in the BMWC.

Each BMWC zone was assigned a unique National Weather Service (NWS) base station to characterize zonal climate (Figure 2). Because of its isolation and remoteness, the Continental Divide zone was assigned the Seeley Lake NWS base station. Base station weather data for 1984 and 1985 were extrapolated to mountainous terrain using the MTCLIM microclimate simulation model (Hungerford et al. 1989). The year 1984 was a near normal to dry year while 1985 had an extremely moist summer and wet fall. Elevation, aspect and slope inputs to MTCLIM were taken as the midpoints of each topographic class (Table 3). MTCLIM was executed for each base station, weather year (1984 and 1985), and topographic class (4 base stations X 2 years X 60 topographic class = 480 simulations). Then, weather for an entire zone was computed by weighting the predicted MTCLIM climate for each topographic class by the land area in that class for a BMWC zone. The land area was computed from the topographic layer in the GRASS GIS system.

Fire

Long term fire history data for the subalpine BMWC were difficult to determine and map because of the rarity of fire-scarred trees in the whitebark pine zone (Keane et al. 1993). However, Keane et al. (1993) determined an approximate fire history from stand structure and the few fire scars they found. The fire interval averaged across all sampled sites was approximately 144 years with a minimum of 55 and a maximum of 304 years. Gabriel (1976) found the average stand-replacement fire return interval for high elevation forests of the southern BMWC was approximately 228 years with the largest intervals exceeding 400 years. Less intense surface fires often occurred at much shorter intervals (20 to 100 years).

RESULTS

Succession

Analysis of the classified cover type layer showed a marked difference between geographic zones in the portion of landscape dominated by subalpine fir (Table 4). BMWC zones 2 and 5 (Swan Front and Middle Fork) have the highest proportion of subalpine fir-dominated communities (15% and 20%, respectively). The Danaher and Rocky Mountain Front zones (3 and 1) have the smallest amount of land dominated by subalpine fir (7% and 9%). Subalpine fir dominance is assumed to be an indication of late successional stages in BMWC subalpine communities. Keane et al. (1993) found it took about 200 to 300 years for subalpine fir to gain dominance in stands previously dominated by whitebark pine.

Pathogens

Spatial summary of forest condition class also shows a difference in the levels of mortality across the BMWC zones (Table 5). Landscapes with the greatest portion of land in the high mortality condition class occur in the Swan Front and Middle Fork (zone 2 has 26% and zone 5 has 24%). Through extensive field inventory, Keane and Morgan (1993) found that the Swan Front, Middle Fork and Rocky Mountain Front regions of the BMWC had the highest levels of whitebark

Table 3 -- Topographic classes for all lands in BMWC analysis area.

Topographic Attribute	Topographic classes 1	2	3	4	5
Elevation (m)	1830-1980	1980-2130	2130-2280	2280-2430	2430+
midpoint	1905	2055	2205	2355	2505
Aspect (Az)	315-45	45-135	135-225	225-315	--
midpoint	0	90	180	270	--
Slope (%)	0-20	20-70	70+	--	--
midpoint	10	45	80	--	--

Table 4 -- Major cover type aggregations by area and percent for each BMWC zone. Whitebark pine types contain cover types 1,3,5,6,7 (Table 1). Subalpine fir types contain cover types 2,4,8,10.

Cover type Aggregations		BMWC Study Zones: Rocky MT Front 1	Swan Front 2	Danaher 3	Cont. Divide 4	Middle Fork 5	Totals
Whitebark pine	(ha)	21,192	39,681	35,801	52,362	27,994	177,030
	(%)	48	54	75	59	48	57
Subalpine fir	(ha)	3,886	10,627	3,479	8,775	10,942	37,709
	(%)	9	15	7	10	20	12
Lodgepole pine	(ha)	725	2,197	3,565	2,424	1,382	10,293
	(%)	2	3	8	3	2	3
Shrub	(ha)	3,014	8,634	1,630	6,427	8,677	28,382
	(%)	7	12	3	7	15	9
Herbaceous	(ha)	4,357	4,561	1,378	6,164	4,209	20,669
	(%)	10	6	3	7	7	7
Rock/Bare Soil	(ha)	10,560	7,207	2,035	12,665	4,705	37,172
	(%)	24	10	4	14	8	12
Totals		43,734	72,907	47,888	88,817	57,909	311,258

pine mortality while stands at or near the Continental Divide had low mortality levels.

Climate - Interaction of Topography and Weather

A summary of general topographic structure for each zone (Table 6) shows the Swan Front and Danaher Zones (zones 2 and 3) having the highest elevations and steepest slopes. The difference in aspects between zones is mostly a result of the border defining the study area. For example, only the eastern portion of the Swan Range is within the study area which would account for its prevailing easterly aspect (Figure 1).

Weather summaries differed across BMWC zones (Tables 7 and 8). In 1984, the Middle Fork (zone 5) seemed to have a colder, wetter fall and higher relative humidities than the other zones (Table 7). The highest precipitation in 1984 (>180 cm) occurred on the Swan Front and Continental Divide (zones 2 and 4). The moist autumn of 1985 occurred in all zones except the Danaher (zone 3), with about 30% of annual precipitation coming in September. Most precipitation fell in the winter and spring during 1984 while late summer and fall in 1985 had high amounts of precipitation for all zones.

Fire

Fire history evidence from Keane et al. (1993) and Gabriel (1976) provides a general description of fire regime by zone considering the lack of BMWC spatial fire

Table 5 -- Forest Mortality Classes by area and percent for forested community types in the BMWC analysis area.

Mortality Class		BMWC Study Zones: Rocky MT Front 1	Swan Front 2	Danaher 3	Cont. Divide 4	Middle Fork 5	Totals
Low	(ha)	8,822	18,309	23,797	13,102	11,652	75,682
	(%)	38	41	41	34	36	39
Moderate	(ha)	10,323	14,802	22,820	16,332	12,799	77,076
	(%)	44	33	39	43	40	39
High	(ha)	4,277	11,317	12,062	8,870	7,530	44,056
	(%)	18	26	20	23	24	22
Total	(ha)	23,422	44,428	58,679	38,304	31,981	196,814

data (Table 6). Historical fires in the Danaher (zone 3) tended to be non-lethal underburns at intervals averaging about 20 to 60 years (Gabriel 1976). These surface fires often killed the fire-intolerant subalpine fir, spruce and young whitebark pine while larger whitebark pine trees often survived. Stand-replacement fires also occurred throughout the Danaher but at much longer time intervals (250 to 400 years) (Table 6). Extensive, stand-replacement fires such as those documented by Ayres (1901) and Losensky (1990) seem to occur every 150 years in the remaining zones, especially the Swan Front, Continental Divide and Middle Fork areas (Table 6).

DISCUSSION

Taken together, the spatial distributions of all landscape process data seems to explain the differences in the rate of decline of whitebark pine in the BMWC. Blister rust infection varies across the BMWC with the Swan Front and Middle Fork zones having the highest level of mortality (Table 5) (Keane et al. 1993). These two zones also have the wettest climates (Tables 7 and 8). A narrow window of temperature and moisture conditions is required for spore germination during the late fall transport of fragile basidiospores from Ribes to the pine needles. MacDonald et al. (1981) mention that temperatures of 10 to 24°C and high relative humidities (greater than 70%) are a requirement for basidiospore germination and germ tube growth. These conditions seem to occur in the Swan Front and Middle Fork zones during September, especially in 1985 (Table 8). The Danaher, with the lowest level of mortality and highest proportion of whitebark pine-dominated communities (Tables 5 and 4), had the driest conditions throughout most of the year, and especially in early fall (Table 8).

Urediospore development, transport and germination is a critical part of the rust life cycle that again requires high temperatures (4 to 28°C) and high humidities (Colley 1918, MacDonald et al. 1981). However, most urediospore production

Table 6 -- General topographical and fire characteristics of BMWC zones.

Descriptive Characteristic	BMWC Study Zones: Rocky MT Front 1	Swan Front 2	Danaher 3	Cont. Divide 4	Middle Fork 5
		Topography			
Elevation (m)	2105	2113	2115	2060	2007
Aspect (az)	West	East	West	West	East
Slope (%)	23	28	24	18	24
		Fire Interval (yr)			
Crown fire	200-300	150-300	300-400	200-300	150-300
Surface fire	?	rare	20-60	?	rare

occurs in the moist, warm environments of mesic sites present in BMWC lower elevations forests (i.e., below 1800 m) where the majority of *Ribes* plants occur. In fact, Keane and Morgan (1993) found less than 5% of whitebark pine stands they visited contained *Ribes*. The majority of basidiospores probably came from *Ribes* communities at lower elevations. Therefore, it would be difficult to rate suitability of urediospore production in the BMWC study zones without low elevation weather data and *Ribes* distribution data. Hoff et al. (1980) mention that probability of rust infection in pine increases with decreasing distance to *Ribes*

Table 7 -- 1984 weather summary by BMWC geographic zone from MTCLIM simulations. 1984 was a near normal weather year.

Climate Parameter	BMWC Study Zones: Rocky MT Front 1	Swan Front 2	Danaher 3	Cont. Divide 4	Middle Fork 5
		Minimum Temperature (C)			
Year	-2.9	-4.5	-5.3	-4.4	-3.6
April	-3.9	-4.1	-5.9	-4.0	-4.0
July	6.6	2.5	0.9	2.5	4.7
Sept	-0.9	-2.3	-3.9	-2.2	-6.9
		Maximum Temperature (C)			
Year	6.3	5.2	5.9	5.4	2.6
April	4.3	4.8	5.0	5.0	3.1
July	20.2	20.4	21.1	20.6	19.1
Sept	10.9	11.5	10.6	11.7	7.3
		Precipitation (cm)			
Year	63.9	182.5	124.9	180.2	174.9
April	12.8	15.3	17.0	15.1	12.8
July	1.2	3.4	4.7	3.3	2.9
Sept	9.6	16.1	9.5	15.9	21.6
		Relative Humidity (%)			
Year	68.2	67.8	62.7	67.3	78.5
April	70.8	69.9	62.5	69.3	76.9
July	56.3	45.6	40.0	45.3	54.7
Sept	61.1	55.9	53.7	55.5	73.0

Table 8 -- 1985 weather summary by BMWC geographic zone from MTCLIM simulations. 1985 had a wet summer and fall.

Climate Parameter	BMWC Study Zones 1	2	3	4	5
		Minimum Temperature (C)			
Year	-4.3	-7.8	-6.2	-7.8	-5.1
April	-1.7	-6.1	-3.7	-6.1	-3.7
July	7.6	3.1	4.6	3.1	6.3
Sept	-0.2	-1.0	-1.1	-0.9	-0.3
		Maximum Temperature (C)			
Year	5.2	3.7	5.1	3.8	1.8
April	7.1	7.9	8.1	8.1	3.5
July	22.8	24.4	24.9	24.6	22.5
Sept	6.8	8.4	8.5	8.6	5.8
		Precipitation (cm)			
Year	121.8	163.8	104.3	161.8	123.5
April	3.8	10.2	7.4	10.1	7.0
July	1.3	0.0	0.6	0.0	0.6
Sept	34.8	50.9	22.3	50.3	29.2
		Relative Humidity (%)			
Year	66.4	61.4	61.7	60.9	76.2
April	69.2	53.1	60.0	52.7	76.0
July	82.5	39.0	41.2	38.7	51.0
Sept	75.1	67.8	66.7	67.2	79.3

plants. So, it would seem that the Swan Front, Middle Fork and Rocky Mountain Front have weather conditions suitable for urediospore development (Table 8).

The limited occurrence of fire during the 1930's to 1960's in the BMWC, coupled with heavy blister rust mortality of whitebark pine, has resulted in a high portion of the landscape being dominated by subalpine fir. The Middle Fork and Swan Front have the highest portions of the land dominated by subalpine fir (20% and 15% in Table 4). The percentages rise to 28% and 21% when only forested stands are examined (i.e., all rock, shrub and herbaceous types are excluded). Only about 9% of the Danaher's forested lands were dominated by fir. However, fires were more frequent in this area (Gabriel 1976), and it took longer for subalpine fir to achieve dominance (about 300 years) because of slower growth rates due to drier growing conditions (Tables 7 and 8).

Blister rust has altered many landscapes beyond historical conditions. Given the cost and remote possibility of eradication, it seems more practical to allow the rust to interact with other natural processes such as gene flow, adaptation and fire. Rust resistant phenotypes of whitebark pine are present on the landscape and are estimated to occur in 1 to 8% of the population (Hoff, personal communication). Over the course of centuries, the interplay between rust and these other processes will eventually create vital and healthy subalpine landscapes.

Notes

LONG-TERM DYNAMICS OF WHITEBARK PINE: TREE-RING STUDIES IN CENTRAL IDAHO

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ABSTRACT

Whitebark pine (*Pinus albicaulis*) tree-ring chronologies of 800 to greater than 1,000 years in length are being developed from the Sawtooth Salmon River region, central Idaho. These data are being used to resolve annual mortality dates of whitebark pine attributed to a widespread mountain pine beetle (*Dendroctonus ponderosae*) infestation that reached epidemic proportions from 1920 to 1940 (Arno and Hoff 1989; Ciesla and Furniss 1975).

Whitebark pine is a relative newcomer to dendrochronology, and, although known as long-lived, slow growing stone pine of the northern Rockies, just how long-lived has not been known until recently. The discovery of the oldest living whitebark pine known in North America was made in central Idaho during this study. This tree exceeds 1,267 years in age with an inside date of 726 A.D., which is not the pith date. The largest whitebark pine on the National Register of Big Trees also occurs here and exceeds 8.5 feet DBH. Research on whitebark pine is now concentrated in the Intermountain region of western Montana and in the Greater Yellowstone ecosystem. However the Sawtooth Salmon River region, near the southern-most edge of whitebark pine distribution (Arno and Hoff 1989), represents a large geographic gap in whitebark pine research and in tree-ring chronologies. Schulman (1956) sampled 1,600 year old limber pines near Ketchum, Idaho, but no other sites with 1,000-year tree-ring chronologies have been built for the northern Rockies (Swetnam pers. comm.). This area is subject to north Pacific weather patterns and Cascade volcanism and is in a transition zone between continental and inland-maritime climates (Arno and Hammerly 1984). The vast pristine high elevation areas are relatively free of human disturbances such as logging and firewood collection. However, these areas have been subject to fire suppression and are increasingly susceptible to recreational impacts on valuable wildlife habitats and watersheds. Long-term tree-ring data may provide information on the whitebark pine forest dynamics essential for a frame of reference for current and future changes in these valued ecosystems.

Our study area is the geographic region north of Galena summit, south of the Middle Fork of the Salmon river, west of the East Fork of the Salmon river and east of the North Fork of the Boise river. Two sites, Upper Sandpass and Sandpass are within the Sawtooth Wilderness area, the Railroad Ridge site is in the White Cloud

mountains, and the Twin Peaks site is on the edge of the Frank Church River of No Return Wilderness near Challis, Idaho. Site elevations are between 2,800 to 3,000 meters (9,200 to 9,800 feet); site areas are between 1.5 to 4.0 hectares (3.7 to 10 acres).

We chose classic dendroclimatic sites (Douglass 1941; Schulman 1956; Fritts 1976) characterized by steep exposed slopes, open grown stands, coarse well-drained soils and southerly aspects to determine if this species had sufficient climatic sensitivity to crossdate. Crossdating is the fundamental tenet of dendrochronology. It is the property that trees within a stand, and cores taken from the same tree, share a common pattern of wide and narrow rings. Preliminary analysis of increment cores collected in 1991 verified that indeed whitebark pine grow distinct annual rings, that intra-annual features are distinguishable from annual rings, and that trees have sufficient age and sensitivity to crossdate.

Samples were then collected from live and dead whitebark pine on the four sites during the growing season 1992 and 1993. At least two cores were extracted from each tree using a 20 inch increment borer. Chronology development consisted of combined traditional techniques of skeleton plotting, visual pattern matching (Stokes and Smiley 1968; Swetnam et al 1985), and use of the computer program COFECHA for trouble-shooting measured series prior to standardization (Holmes 1986). Computer program Arstan was used to develop the final chronologies (Cook and Holmes 1984).

High elevation whitebark pine forests in the study area are composed of large diameter, old whitebark pine snags mixed with stands of live whitebark pine and sub-alpine fir (*Abies lasiocarpa*). Mass mortality of mature age class trees has been attributed to a mountain pine beetle outbreak transmitted from lower elevation lodgepole forests to high elevation stands of whitebark pine. This outbreak reached epidemic proportions from 1920 to 1940 and was reported from southern Canada to Wyoming (Arno and Hoff 1989; Ciesla and Furniss 1975). However, timing and patterns of mortality within and between stands in central Idaho are largely unknown; several questions remain. Did the numerous dead overstory trees within stands succumb in a short period of a few years, or did they die over longer periods? Are mortality events synchronous among stands in the region? What were the climate conditions before, during and after the mortality? What are the interactions between climate variables and beetles? Is the mortality event unprecedented? To begin to address these questions, I used crossdated tree-ring series to resolve annual mortality dates of whitebark pine. A methodology is established to date mountain pine beetle caused mortality of whitebark pine based on three lines of evidence:

1. Observed adult beetle galleries on the bole.
2. Blue stain fungus present in sapwood.
3. Date of outer ring referenced to a crossdated ring-width chronology from the stand in which outbreak occurred.

A sampling strategy based on distance methods to determine the relative density of mountain pine beetle-killed trees and to core these individuals was used during the of summer 1993. If the dead tree met the first two criteria outlined above, it was coded a beetle kill (B), if adult beetle galleries were not present, but blue stain fungi was, it was coded probable beetle-kill (PB). Blue stain fungi had to be present for at least 0.25 inches in the outer sapwood to be considered valid criteria. Dead trees and subfossil wood without beetle galleries and blue stain were coded unknown dead (U). On both the Upper Sandpass and Sandpass sites, the number of crossdated death dates of large diameter, mountain pine beetle-killed pine, have a maxima at 1930. Approximately 20 percent of the dead trees on the Sandpass site and 60 percent of the dead trees on the Upper Sandpass site were beetle-killed from the 1930 period. Preliminary results of this study suggest the history of 800 to 1000 year old whitebark pines in this region can be described and used to extend understanding of subalpine zone dynamics.

Millennial length whitebark pine tree-ring chronologies are unique ecological time-series that may contain useful endogenous stand information, as well as provide proxy records of climatic change. Luckman (1993), in preliminary analysis of treeline chronologies from the southern Canadian rockies, suggests that whitebark pine ring-width chronologies correlate with summer temperature. Because temperature is important for synchronizing the various life stages of the mountain pine beetle (Amman and Cole 1983; Bentz et al. 1991), long-term variations of temperature may be useful to entomologists studying beetle populations. The interaction of whitebark pine, Clark's nutcracker (*Nucifraga columbiana*) and mountain pine beetle is a unique coupled feedback system of the subalpine zone of North America. The positive feedback, represented by the mutualistic relationship of whitebark pine and Clark's nutcracker (Tomback 1982; Hutchins and Lanner 1982), and the negative feedback, represented by predation of mountain pine beetle on whitebark pine, is a natural dynamical system that is likely capable of producing complex behavior. The 1,000 year tree-ring chronologies developed from whitebark pine may provide useful information for understanding this system.

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Notes

WHITEBARK PINE REGENERATION PROCESSES IN THE SUNDANCE BURN OF IDAHO

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ABSTRACT

The Selkirk Range in northern Idaho is an area heavily infected by white pine blister rust (*Cronartium ribicola*). In 1967, over 22,600 ha of montane and subalpine zone forest were severely burned in this range, including seral whitebark pine (*Pinus albicaulis*) communities. The burn, named for the point of origin of the fire, Sundance Mountain, enabled us to compare whitebark pine regeneration densities in a heavy blister rust area with regeneration densities in the similarly-aged Sleeping Child and Saddle Mountain burns of western Montana. These latter two burns occur in areas of lower blister rust incidence. We also compared the frequency and severity of blister rust infection between whitebark and western white pine (*Pinus monticola*) and attempted to determine the factors that might predict incidence and severity of infection in both species.

METHODS

For comparative purposes, the methods were similar to those used in the Sleeping Child and Saddle Mountain burn studies. Beginning at the edge of the unburned whitebark pine seed source at the southeastern end of the burn, we established a 3.4 km transect heading northeast into the burn. The transect essentially followed an elevation isocline, ranging between 1,775 and 1,849 m, to control for the influence of elevation on whitebark pine densities. We established two parallel plots every 150 m along the transect, for a total of 46 plots. Each plot was 50 m long and varied in width with local density of whitebark pine from 2.5 to 10 m in predetermined increments. All whitebark and western white pine regeneration was measured for height, aged, and examined for symptoms of blister rust, following the Ecodata methodology (R. E. Keane and R. J. Hoff). For whitebark pine, a "regeneration site" supported either a single seedling or a cluster of seedlings; the latter results when more than one seed in a nutcracker cache germinates.

In the seed source near the edge of the burn we surveyed three widely separate plots, each 900 m^2 in area. We examined the condition and infection levels of all live, mature whitebark pine and measured snags and live trees for dbh.

We used Logistic Regression Analysis to examine the relationship between incidence of infection and the independent variables age, height, and distance from

the whitebark pine seed source for both whitebark and western white pine. In order to determine the predictive factors associated with severity of infection, we used Stepwise Regression Analysis with the same variables, using only infected seedlings. Other statistical tests used included Spearman Rank Correlation Analysis and Two Sample t-tests.

RESULTS AND DISCUSSION

We determined that the density of whitebark pine regeneration in the Sundance Burn was significantly lower (one-sixth and one-ninth, respectively) than that found in the Sleeping Child and Saddle Mountain burns about 25 years post-fire. Similar to both Montana burns, a scatterplot of whitebark pine density vs. distance from the seed source followed a negative exponential distribution--a pattern that is probably a consequence of nutcracker seed caching behavior.

For whitebark pine, 29% of the regeneration sites had seedlings with blister rust symptoms; for western white pine, 22% of the regeneration sites had seedling with blister rust symptoms. Only three seedlings each of whitebark and western white pine were dead and showed blister rust symptoms. Thus, to date blister rust was not a major cause of mortality and did not account for the lower whitebark pine regeneration density observed. However, the plots in the whitebark pine seed source revealed few, live whitebark pine trees. Apparently, prior to the 1967 Sundance fire a mountain pine beetle infestation resulted in widespread tree mortality. In addition, about a third of the living, cone-producing trees were infected with blister rust. Thus, lack of seed production to date probably accounted for the low levels of whitebark pine regeneration and not mortality caused by blister rust.

Nonetheless, the outlook for regeneration in the Sundance Burn is not optimistic. Age and height of regeneration were two important predictors of incidence of blister rust infection for both pine species. By way of illustration, the average age and height of infected whitebark pine seedlings were nearly twice that of uninfected seedlings. Height alone was the major predictor of severity of infection (number of cankers per seedling). Thus, as seedlings become larger, they have a greater chance of becoming infected, and the severity of infection may increase. Consequently, uninfected seedlings may become infected as they grow.

Even though the regeneration process may be slow, it is likely that much of the surviving regeneration will be resistant to blister rust. Only after resistant trees are widespread and cone-producing will restocking of burns and clearcuts with whitebark pine again occur in a natural timeframe. However, the current situation has management implications: any large-scale prescribed burns will not restock well. Small-scale burns may require thinning of subalpine fir (*Abies lasiocarpa*) to eliminate competition with regenerating whitebark pine.

Notes

SUSCEPTIBILITY OF WHITEBARK PINE SEEDLINGS ARTIFICIALLY INOCULATED WITH BLISTER RUST

Presented by Ray J. Hoff

Three-year-old seedlings from nine stands were inoculated in August 1992. Data will be presented for the June 1993 rust inspection for presence and number of needle spots, September 1993 and March 1993 inspection for cankers.

There are two groups of stands represented. Those that have had more than 90% mortality caused by blister rust (three stands) and those with low to moderate mortality, from none to 60%, average was about 30% (six stands).

Data were as follows:

		----------seedlings----------			
		----June 1993----		Sept	March
	Total	with needle spots	needle spots per m	1993 with cankers	1994 with cankers
	#	%	#	%	%
High Mortality Stands	326	93	11	55	59
Low Mortality Stands	371	92	10	77	79

Needle infection among families within the high mortality stands varied from 2 to 25 spots per meter of needle tissue. In September 1993 the percentage of cankered seedlings varied from 6 to 90% and in March 1994 varied from 17 to 100%. Family variation for the low mortality stands was 3 to 16 needle spots per meter and 59 to 100% cankered seedlings. One susceptible seedling had 26 cankers.

Notes

SILVICULTURAL TREATMENTS AND WHITEBARK PINE PLANTATION AND REGENERATION TRIAL RESULTS

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ABSTRACT INTRODUCTION

Plantation and regeneration trials for whitebark pine (*Pinus albicaulis*) are beginning to show dramatic results (McCaughey 1993a). There are 7 established plantations in Region 1 and an eighth that will be installed in 1994. The first whitebark pine plantation was established on the Gallatin National Forest on Palmer Mountain near Gardiner, MT in 1987. There are three plantations on the Gallatin (GNF)and four on the Lewis and Clark N.F. (L&CNF).

There are several completed and ongoing regeneration trials evaluating whitebark pine natural and artificially seeded regeneration under a variety of seedbed and site conditions. While many of these trials are ongoing the Palmer Mountain trials are now 5 years old and survival results will be discussed in this paper.

PLANTATIONS

Whitebark pine plantations are relatively new in relation to plantations of other western conifers. Therefore, information is limited on growth and survival of the planted whitebark pine. Most results are preliminary but are providing important results with each new growing season. The seven established plantations on the Gallatin (GNF) and Lewis and Clark (L&CNF) National Forests are as follows:

1 Palmer Mountain (GNF) - planted 1987

2 Cooke City (GNF) - planted 1991

3 Northfork Burn (GNF) - planted 1992

4 Falls Creek (L&CNF) - planted 1989

5 Cyanide Creek (L&CNF) - planted 1991

6 East Fork Cyanide Creek (L&CNF) - planted 1992

7 West Fork Cyanide Creek (L&CNF) - planted 1993

Gallatin National Forest Plantations

Palmer Mountain

The Palmer Mountain plantation was planted on the Gallatin National Forest in

August of 1987 on a high ridge (8300 ft). Survival and growth measurements were taken on 300 planted whitebark pine seedlings in 1988, 1989, 1992, and 1993. There are three replications with 100 trees in each.

Total plantation survival has dropped considerably from 91 percent in the first year after planting (1988) to 26 percent 5 years later in 1992 (fig. 1). The 1993 results at 23 percent survival suggest that the majority of the mortality has occurred in the first 5 years and mortality may be only minimal in the future.

The low overall survival rate of 23 percent is misleading when you evaluate survival of whitebark pine on the basis of microsite conditions. Survival of trees is only 2 percent in swales that are susceptible to frost and pocket gopher (*Thomomys tolpoides*) activity. Gopher activity is visually higher in the swales where soils are deeper and grasses and forbs are more abundant. Shrub competition is highest on the bench and upper slope sites.

Survival increases to 20 percent on 15 percent slopes immediately adjacent to the swales (fig. 2). Gopher activity is still high on these 15 percent slopes, however, the effect of frost may be reduced. Survival is 47 and 44 percent on benches and 9 percent slopes that are out of the frost pocket influence. Pocket gopher activity is visually less on these upland planting sites. The survival on benches and 9 percent slopes in year 6 is nearly 10 percent less that the year 5 results suggesting that mortality has yet to stabilize.

Cooke City and Northfork Burn

The Cooke City and Northfork Burn plantations on the Gallatin National Forest are relatively new and have been evaluated for growth and survival. The Cooke City plantation was planted in 1991, beginning height measurements were taken on planted trees in 1992 and survival and growth measurements are scheduled for 1994. The Northfork Burn near West Yellowstone, MT was planted in 1992. Within the first year district personnel noticed preferential feeding on the whitebark pine seedlings by elk (*Cervus elaphus nelsoni*). This 1000 tree plantation is being monitored by the Gallatin National Forest.

Lewis and Clark National Forest Plantations

All whitebark pine plantations on the Lewis and Clark National Forest have been located in stands burned in 1988. All four plantations have standing dead trees that provide shade for planted trees. The Lewis and Clark plantations are being maintained and measured by the Rocky Mountain Ranger District.

Falls Creek

Four year survival of whitebark pine is around 80 percent for trees planted in Falls Creek (fig. 3). Two-year-old tubelings were planted in 7 rows with one, two, three trees planted per planting spot. Two or three trees were planted at some planting

spots for evaluating inter-tree competition of planted whitebark pine. Stocking as indicated by planting spot survival is around 86 percent.

Cyanide Creek

The Cyanide Creek plantation was established in 1991 and has only been monitored for 2 years. Survival of all planted whitebark pine is around 93 percent two years after planting (fig. 4). Stocking (planting spot survival) is nearly 97 percent on the Cyanide Creek plantation.

East Fork Cyanide Creek

The East Fork Cyanide Creek plantation was established in 1992 with first-year survival counts and growth measurements of whitebark pine seedlings were taken in 1993. First year survival was around 94 percent and planting spot survival at over 95 percent (fig. 5)

West Fork Cyanide Creek

The West Fork Cyanide Creek plantation was established in 1993 and the first-year survival counts and growth measurements of whitebark pine seedlings will be taken in 1994.

REGENERATION TRIALS

Regeneration information for whitebark pine has been sketchy and limited to only a few site conditions (McCaughey in press). Some regeneration trials have been completed while others are ongoing. Completed and ongoing trials are providing managers with important site specific information for natural and artificially seeded regeneration. Some of these trials are as follows:

1 Palmer Mountain - seeded regeneration with burned, scarified, and non-scarified seedbeds in a clearcut-with-reserve conditions under 0, 25, and 50 percent shade cover (McCaughey 1990 and ongoing).

2 Cooke City - natural regeneration on moist and dry sites under burned and salvage logged conditions (McCaughey-ongoing).

3 Cooke/Washburn - natural regeneration on moist and dry sites under burned and unburned non-logged conditions (Tomback-ongoing).

4 Sleeping Child - natural regeneration under wildfire conditions (Tomback and others 1990; Tomback and others 1992).

5 Beartooth Plateau - natural and seeded regeneration under natural timberline conditions (Mellmann 1993 and ongoing).

6 Shoshone National Forest - natural regeneration as influenced by fire frequency (Morgan and Bunting 1990)

This paper will focus on the regeneration results from the Palmer Mountain trials.

Palmer Mountain Regeneration Trials

The Palmer Mountain regeneration trials were initiated in 1987 and repeated in 1988 after a successful prescribed burn. The 1987 and 1988 trials were designed to evaluate regeneration success and subsequent survival of seeded whitebark pine under three shade levels (0%, 25%, 50%) and on three seedbed conditions (mineral, litter, burned). There were three replications of each shade level and seedbed combination. The 1987 trials will not be discussed here because burning treatments were not available.

Survival results for the 1988 seeded plots show that by year five shading had a significant effect. Early trial results by McCaughey (1990) showed that survival on shaded plots was only slightly higher than on open grown plots. The 5-year survival of open grown seedlings was around 5 percent and increased to 25 and 32 percent for the 25% and 50% shade level, respectively (fig. 6). Survival had increased from year 1 to year 2 due to delayed germination of whitebark seed (McCaughey 1993b). Survival has been steadily decreasing since year 2.

Open grown seedlings had the lowest 5-year survival (fig. 6). Within this group of seedlings, those germinating on a litter seedbed had a 1 percent survival rate compared to 9 percent for mineral and 7 percent for burned seedbeds (fig. 7). As shade cover increased from zero to 25 and 50 percent survival on litter seedbeds increased and even exceeded survival on burned seedbeds (figs. 8 & 9). Survival of seedlings was always highest on mineral seedbeds but not significantly different from the shaded litter seedbeds.

DISCUSSION

Plantings on a larger variety of site conditions are needed to fully evaluate suitable sites for whitebark pine plantations. Some survival and growth information is available on plantations but because of the young nature of these plantings it will be a while before we can fully help managers.

Regeneration information is a little further along than plantation data and much of what we now know about natural and seeded regeneration can be used by managers. Regeneration survival on a wider variety of site and habitat conditions needs further investigation to better help with management of whitebark pine in our high elevation forests. Regenerating remote high-elevation sites with whitebark pine seed is being considered as a viable management option with the advent of Ecosystem Management. Information is needed on improved seeding techniques for whitebark pine for ecosystem restoration work in remote areas.

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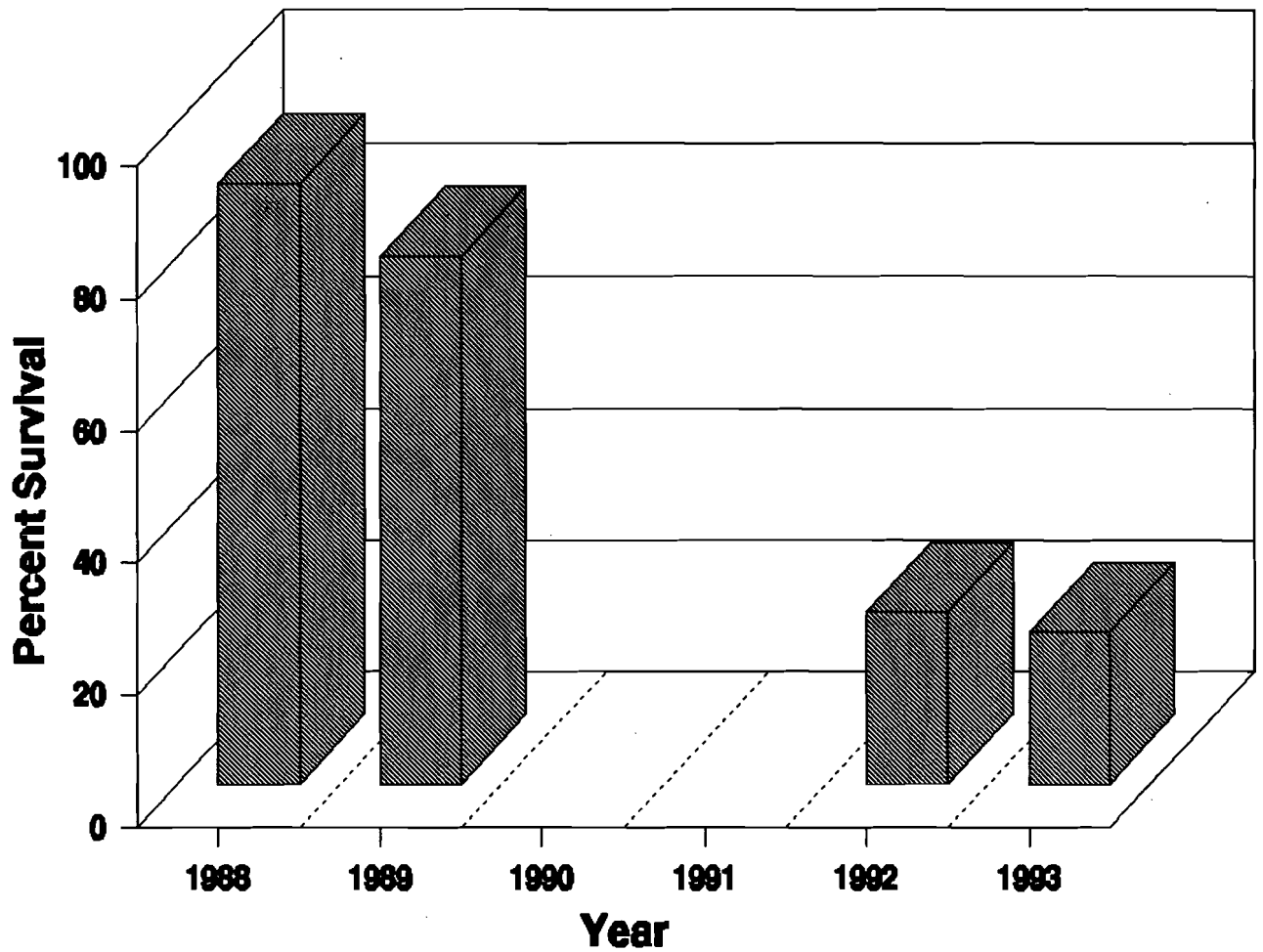

Figure 1. Percent survival of 1987 planted whitebark pine from 1988 to 1993 - Palmer Mountain, Gallatin National Forest.

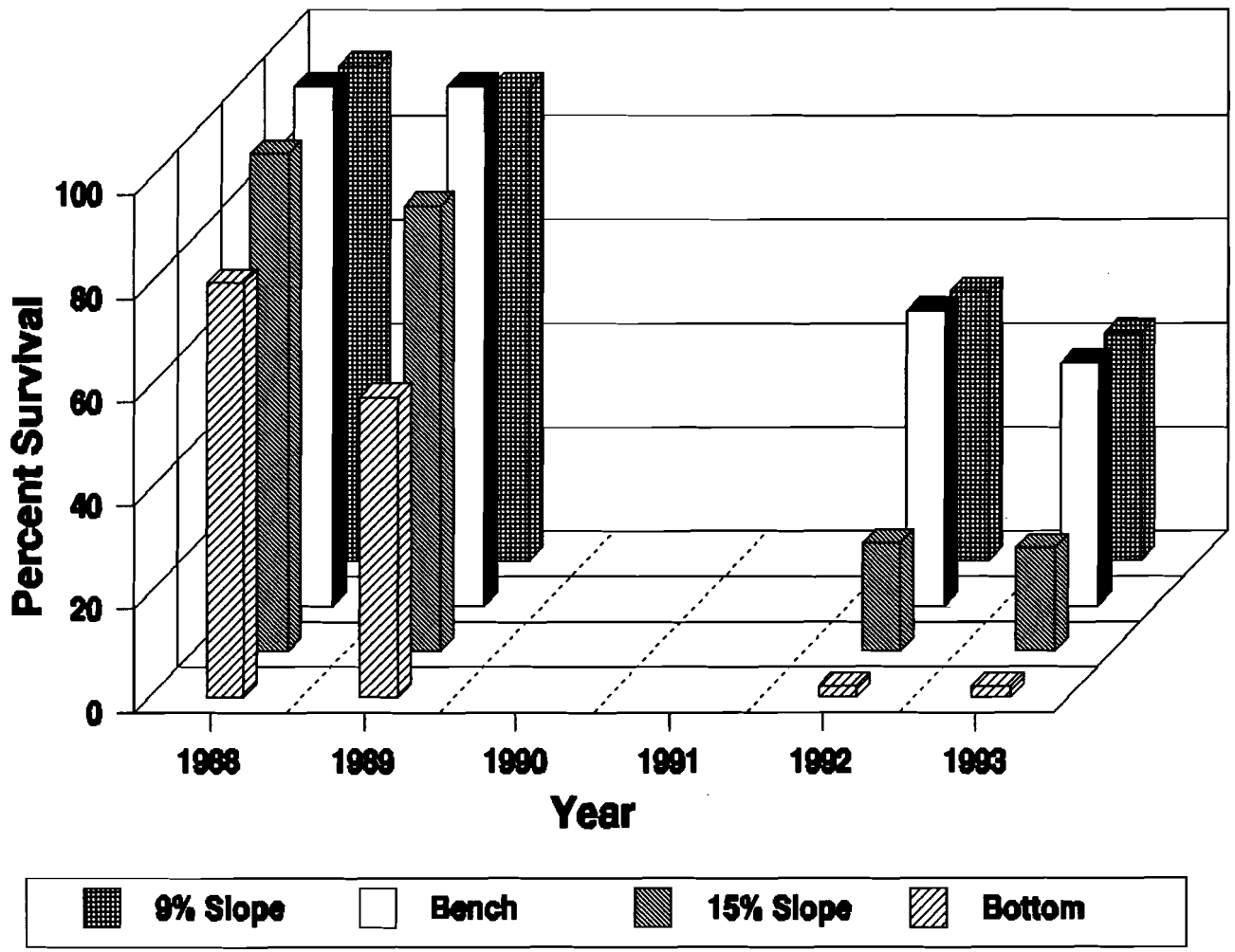

Figure 2. Percent survival of 1987 planted whitebark pine by physiographic location from 1988 to 1993 - Palmer Mountain, Gallatin National Forest.

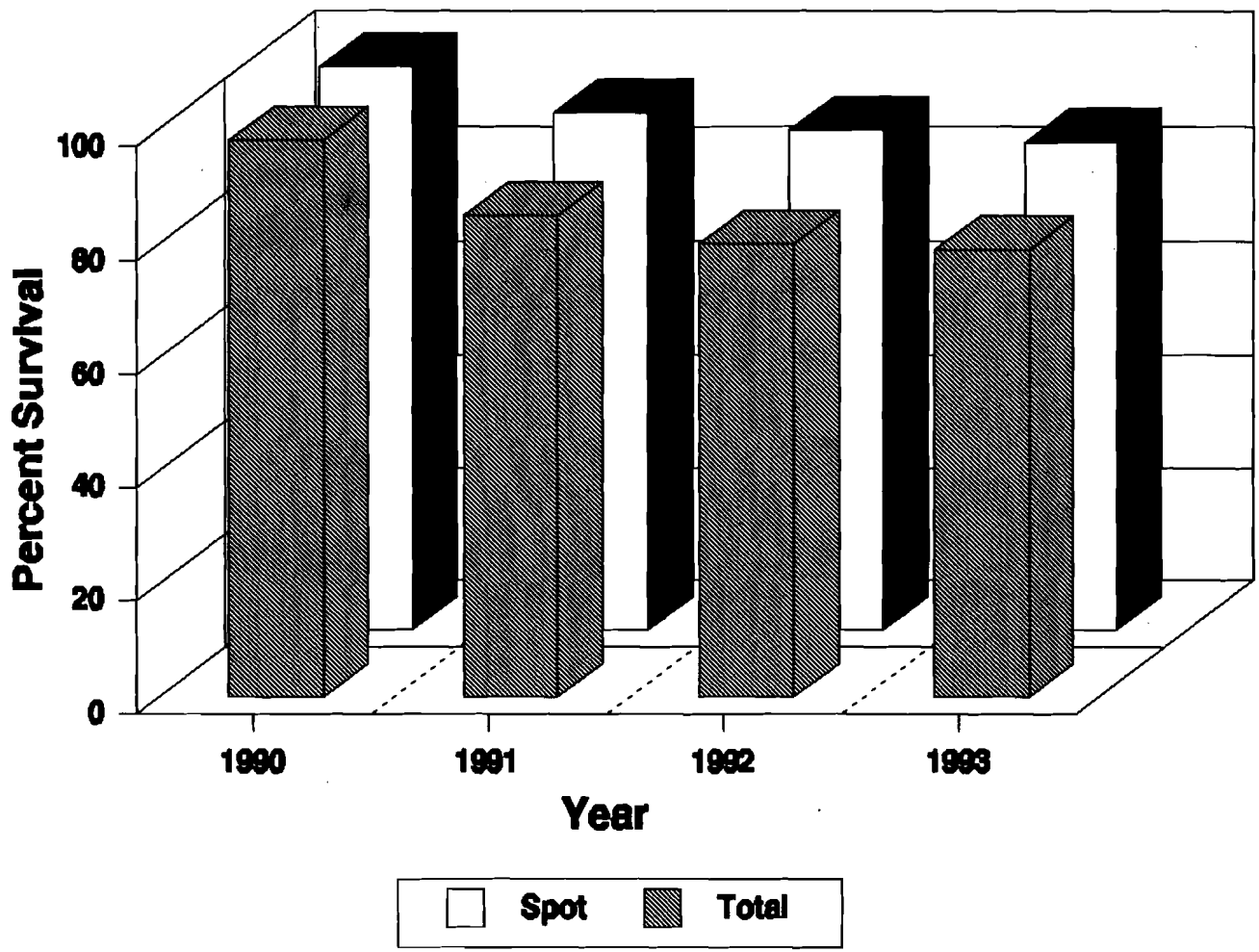

Figure 3. Percent survival of 1989 planted whitebark pine - total and planting spot survival - Falls Creek, Lewis and Clark National Forest.

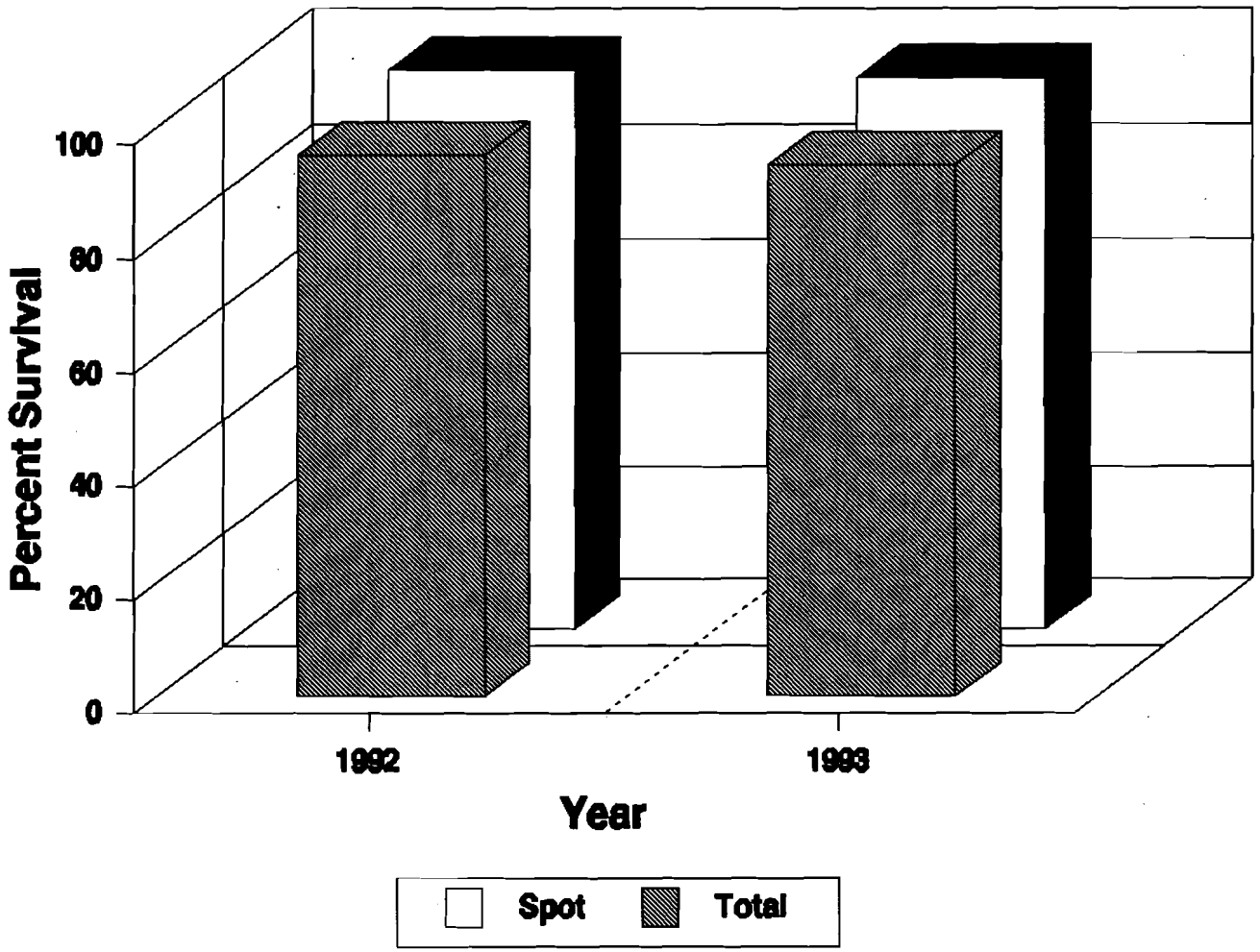

Figure 4. Percent survival of 1991 planted whitebark pine - total and planting spot survival - Cyanide Creek, Lewis and Clark National Forest.

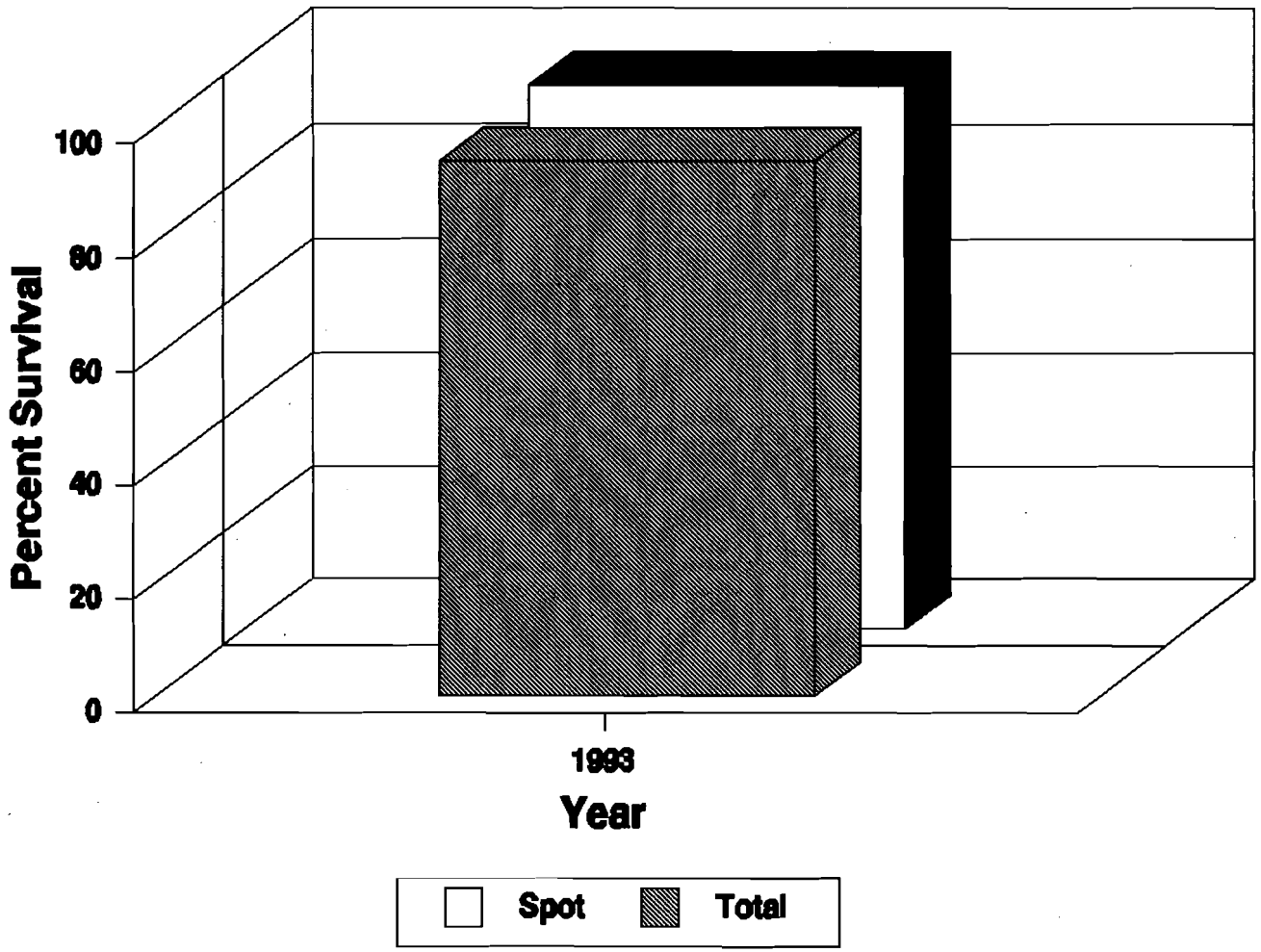

Figure 5. Percent survival of 1992 planted whitebark pine - total and planting spot survival - East Fork Cyanide Creek, Lewis and Clark National Forest.

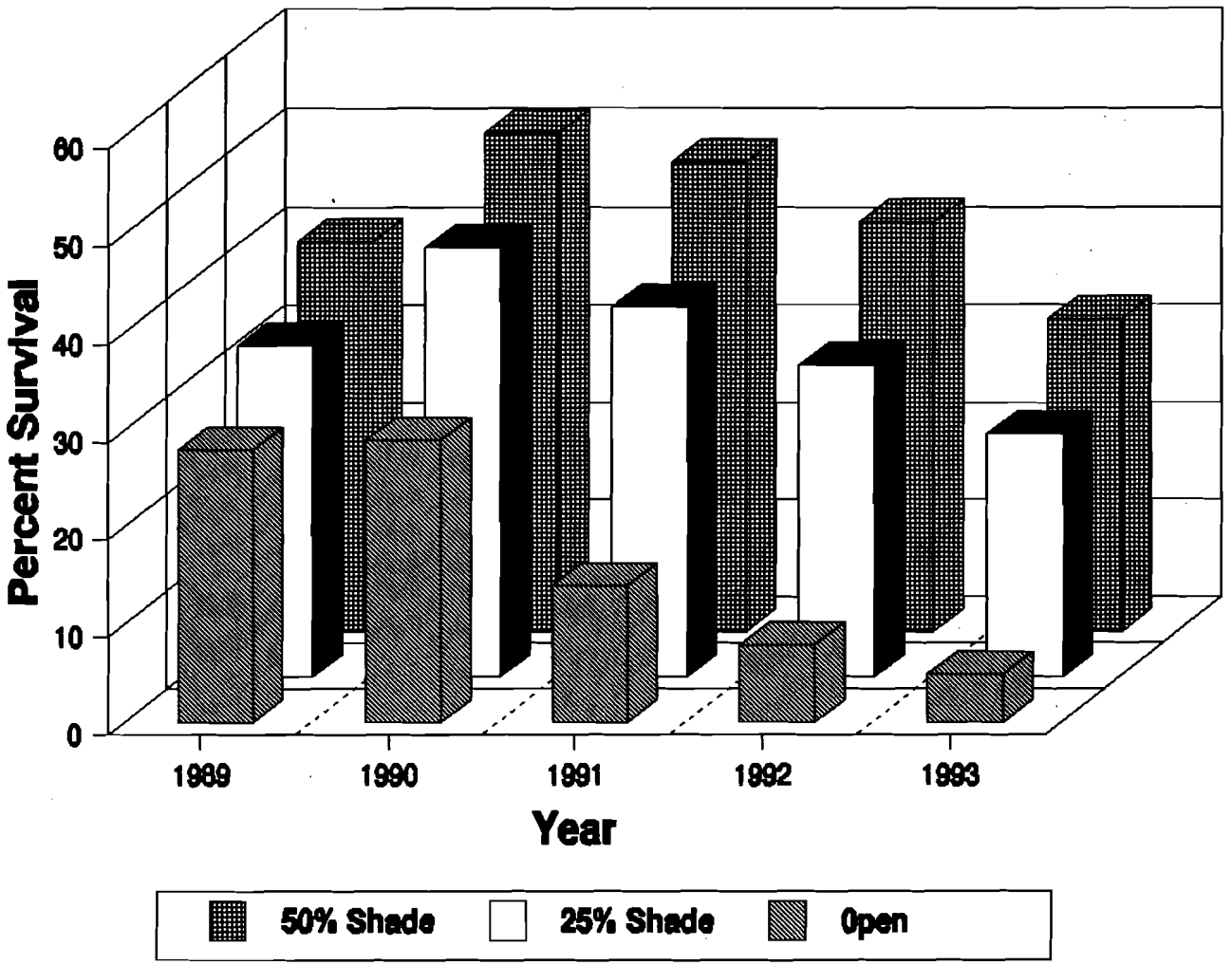

Figure 6. Percent survival of 1988 seeded whitebark pine seedlings by percent shade cover, 1 to 5 years after seeding - Palmer Mountain, Gallatin National Forest.

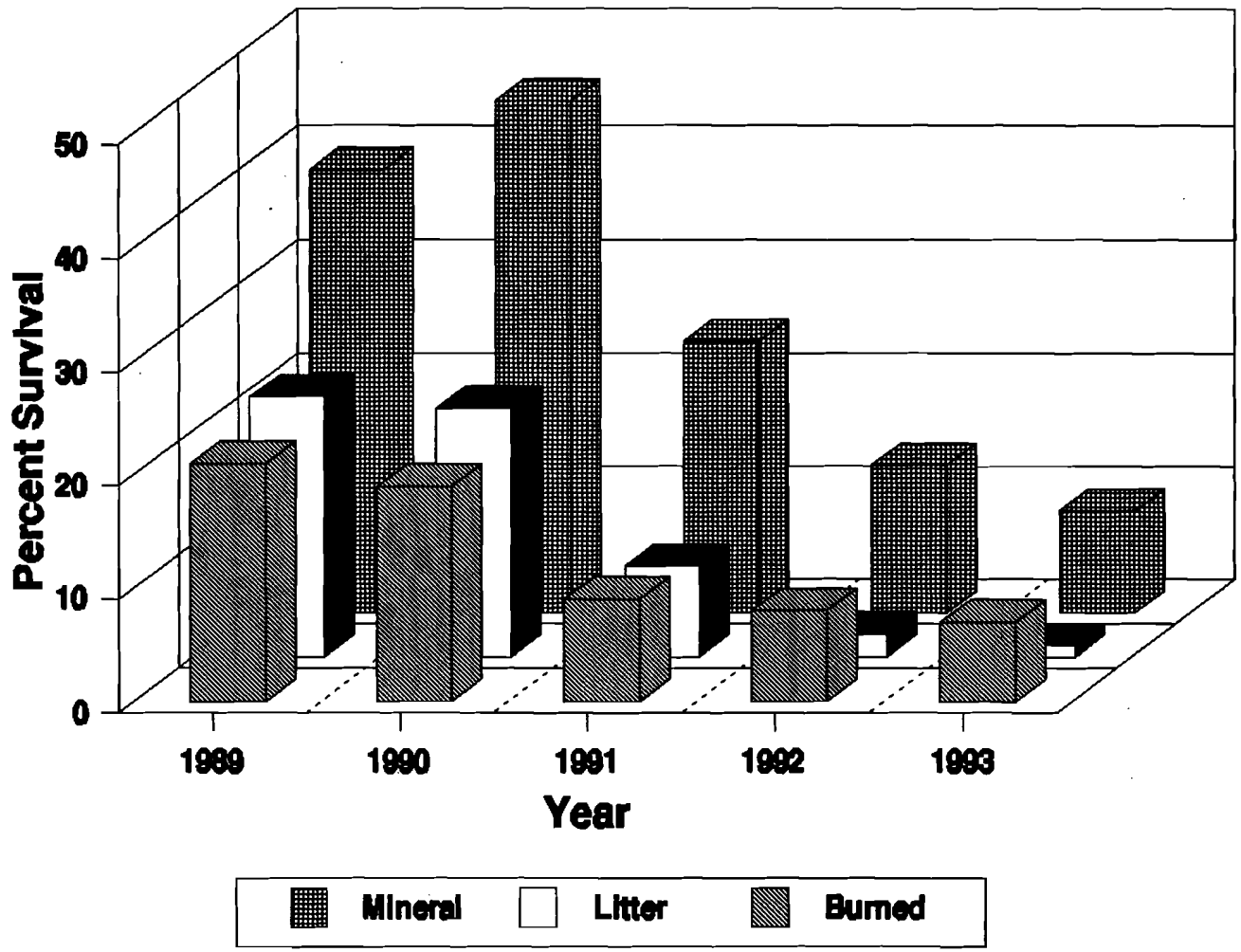

Figure 7. Percent survival of 1988 whitebark pine seedlings under open grown conditions on mineral, litter and burned seedbeds, 1 to 5 years after seeding - Palmer Mountain, Gallatin National Forest.

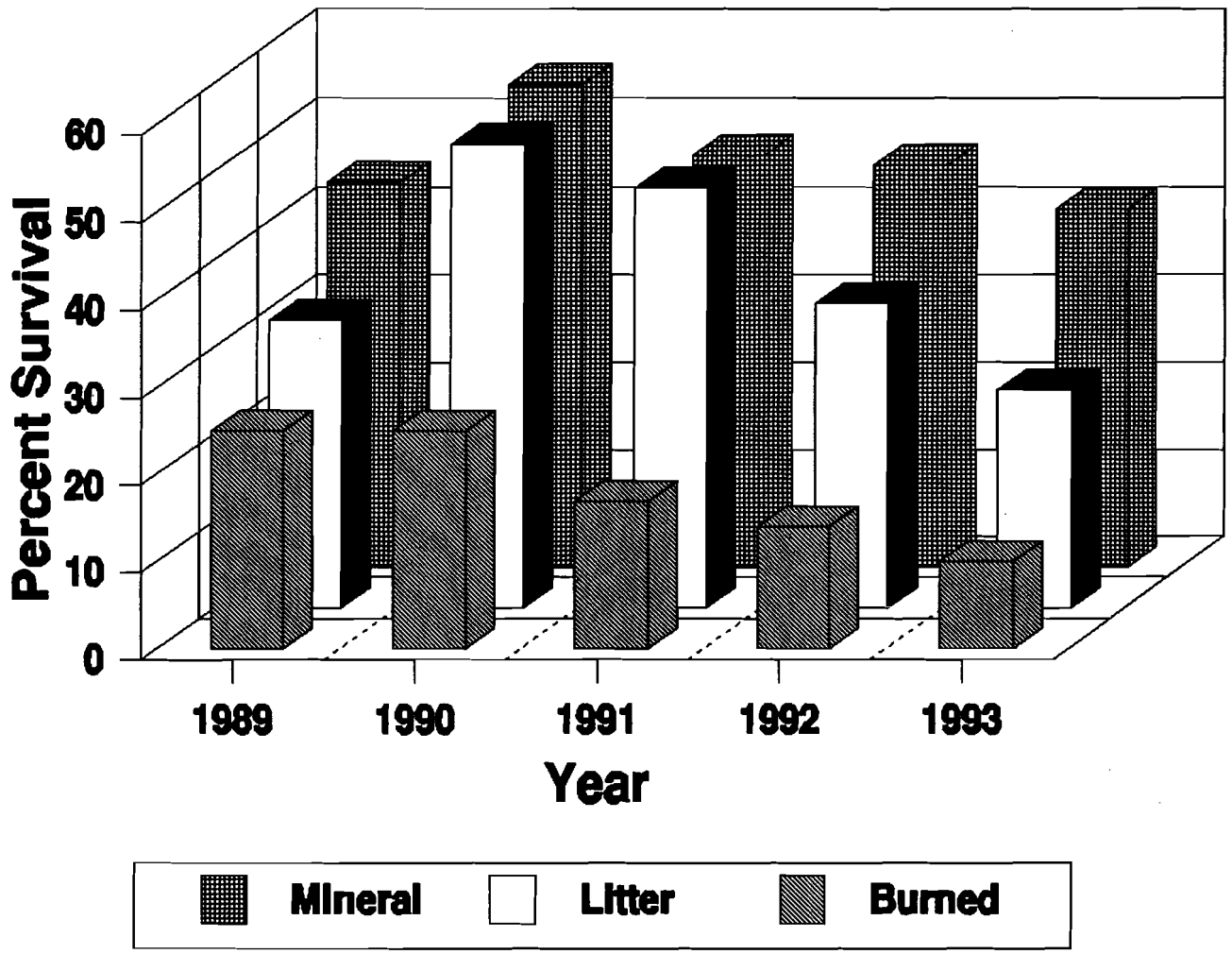

Figure 8. Percent survival of 1988 seeded whitebark pine seedlings under 25 percent shade cover on mineral, litter and burned seedbeds, 1 to 5 years after seeding - Palmer Mountain, Gallatin National Forest.

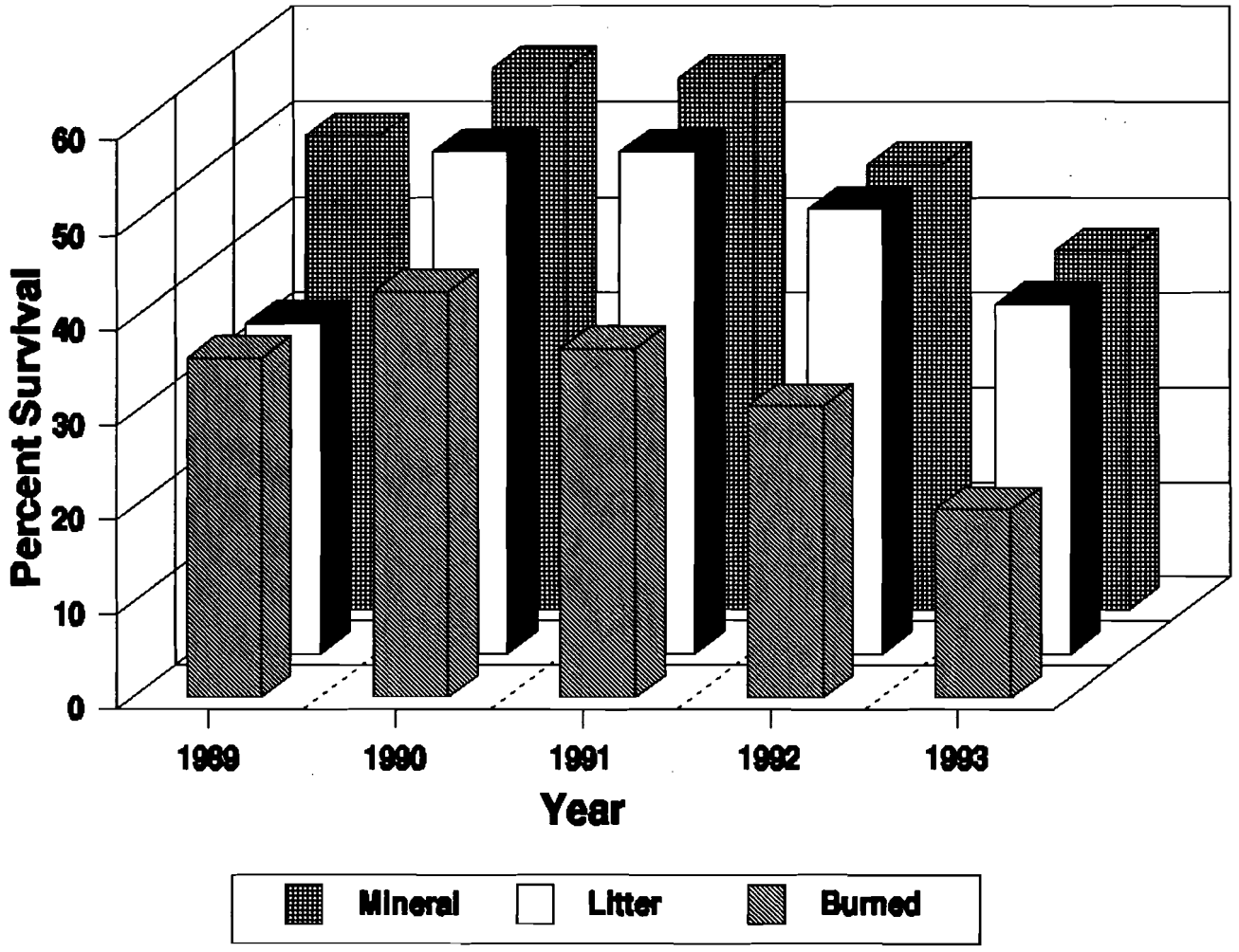

Figure 9. Percent survival of 1988 seeded whitebark pine seedlings under 50 percent shade cover on mineral, litter and burned seedbeds, 1 to 5 years after seeding - Palmer Mountain, Gallatin National Forest.

Notes

ECOLOGICAL MAPPING of WHITEBARK PINE in GLACIER NATIONAL PARK

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ABSTRACT

White pine blister rust and other factors have devastated northwest whitebark pine stands. Little is known of whitebark pine ecosystems in the 11 national parks where it occurs. A project to study whitebark pine communities in parks in the Rocky Mountain region will begin in 1995. Study goals are to understand the historical distribution of whitebark pine in Glacier NP and obtain detailed information on its current status there and in Grand Teton and Yellowstone NP's. ECODATA techniques will be used to gather plant community composition and stand characteristics. Permanent plots will be established for trend monitoring.

INTRODUCTION

Whitebark pine, a component of high-elevation forests in 15 national park areas in western United States and Canada (Fig. 1), is threatened by an introduced fungus, white pine blister rust (*Cronartium ribicola*), and fire suppression. In its northern range, many whitebark pine stands have declined more than 90% (Fig.2) (Kendall and Arno 1990; Kendall, in press). Mortality has been rapid in areas like western Montana, where 42% of whitebark pine trees have been killed in the last 20 years and 89% of the remaining trees are infected with rust (Keane and Arno 1993). Although drier conditions have slowed the spread of blister rust in whitebark pine's southern range, infection rates there, are increasing and large die-offs are expected, eventually (Fig.3) (Kendall, in press).

The impact of white pine blister rust has been felt in National Park Service (NPS) areas throughout the U.S.; it has affected 7 pine species in 56 parks (Table 1). While it causes damage in eastern white pine (*P. strobus*), it has not resulted in wide-spread mortality. The significant rust-induced mortality experienced by sugar (*P. lambertiana*) and limber (*P. flexilis*) pine in some areas, is expected to spread (Kendall and Arno 1990, Kinloch and Dulitz 1990). Western white pine (*P. monticola*) has been decimated throughout much of its range. However, because it is commercially valuable, it has been the focus of extensive, long-term research and rust-resistant strains have been bred. While NPS conservation mandates for western white pine certainly merit attention, the plight of whitebark pine appears to be more dire at this time.

Presently, blister rust infection rates are lower in the southern, drier portions of whitebark pine's range. Whitebark pine cone monitoring transects in Yellowstone National Park (YELL) were surveyed for blister rust in 1992 and 1993 (Reinhart 1994). Although blister rust was documented in the Greater Yellowstone ecosystem by 1950, no evidence of rust was found at the transect sites.

Whitebark pine infected with rust is reported in the Cooke City area on the eastern boundary of YELL (Reinhart 1994) and high rust infection levels occur to the west of YELL (Fig.3). It is likely that whitebark pine in this area will experience rust-induced mortality in the future.

The alarming loss of whitebark pine has broad repercussions for community and landscape processes. As whitebark pine declines, mast for wildlife is diminished and carrying capacity lowered (Kendall and Arno 1990). This hinders grizzly bear recovery and may be catastrophic to Greater Yellowstone Ecosystem grizzlies for whom pine seeds are a critical food. In areas of high whitebark pine mortality, lack of shelter may have been, in part, responsible for declines in associated subalpine fir in some areas (Keane 1992). Predicted changes in former whitebark pine communities include the absence of reforestation after disturbance in high-elevation, rocky and windblown sites, and lowered tree-lines. Finally, stream flow and timing will be altered as snow accumulation and persistence changes with vegetation.

Park Service ability to deal with these threats is limited by how little is known of whitebark pine communities (Kendall 1992). Of the 11 U.S. parks with whitebark pine, most had basic vegetation maps but only half knew the amount of area covered by whitebark pine (Table 2). Where available, the whitebark pine coverage figures are not necessarily comparable. Some estimates only included areas where whitebark pine was dominant or codominant, while others included the area of all communities with whitebark pine present. Where blister rust infection rates are high, past mapping efforts underestimate the natural occurrence of whitebark pine.

Because none of the parks have actually surveyed whitebark pine, information on its status in most areas is based on casual, at times, out-dated observation or is unknown (Kendall 1992). For example, the whitebark pine mortality estimate for Glacier N.P.(GLAC) (>90%; Table 2) is based on unquantified observations made in a limited area in the early 1970's. Rocky Mountain N.P., Colorado lists whitebark pine as present but it is unlikely to occur so far south of its range and was probably confused with limber pine (*P. flexilis*). Although blister rust is verified as present in 8 parks, because most park staffs are unfamiliar with it, its presence was unknown or it was assumed absent in 7 parks. Few parks have information on the effects of fire suppression in their whitebark pine communities.

Whitebark pine forests in national parks have received little research and management attention (Kendall 1992). Canadian Parks Service reported no on-going research or management in whitebark pine communities. In the United States, only YELL is currently conducting whitebark pine research. Some studies on post-fire succession and fire effects on soil seed banks in YELL include whitebark pine stands. YELL has monitored cone production in whitebark pine

stands since 1981. No other parks are conducting or sponsoring research or monitoring of whitebark pine.

To begin learning about whitebark pine in national parks, I propose to study whitebark pine communities in the Rocky Mountain national parks. This project will provide information needed to develop a conservation strategy and will contribute to some whitebark pine rescue efforts already in place.

OBJECTIVES

The goal of this work is to gain an understanding of the historical distribution of whitebark pine and detailed information on its current status in parks in the Rocky Mountain region. Whitebark pine community maps exist for Grand Teton N.P. (GRTE) and YELL. These areas will be surveyed to assess whitebark pine status and blister rust infection. In GLAC, where moister conditions associated with high levels of blister rust infection prevail, and where less is known about the whitebark pine communities, more extensive work is warranted. Here, whitebark pine communities will be mapped and intensively surveyed for rust damage.

Specific objectives are:

1. Map the natural distribution of whitebark pine communities in GLAC. Digitize results for inclusion as a GIS layer.

2. Document whitebark pine tree mortality rates and causes. Assess the effect of mortality on other plant community members.

3. Identify, mark, and, when possible, collect seed from rust-resistant trees for inclusion in future breeding programs.

4. As opportunities arise during field sampling, collect and store seed to represent the breadth of phenotypic and geographic variation.

5. Establish a monitoring network in GLAC, YELL, and GRTE to track the status and trends of whitebark pine. Obtain baseline data for network.

METHODS

WBP Distribution in GLAC

Mapping: Whitebark pine occurs throughout the high elevations of GLAC in the most inaccessible sites in the park. Mapping will sample 82,800 ha (204,600 ac) of potential whitebark pine habitat (Fig.4). Areas in GLAC to be mapped during field work will be identified from aerial photographs (B&W, 1:40,000 scale flown 1990-91), personal observations and logistical considerations. After examining the whitebark pine communities in each study area, community boundaries will be drawn on 7.5 min. orthophoto quads while in the field. The minimum mapping unit

will be 1 acre. Remaining areas of whitebark pine, not visited in the field, will be mapped with aerial photo interpretation and extrapolation from field observations. Results will be digitized and will be added to GLAC's GIS.

Sampling: Ecological inventories of each study area will allow identification and description of all whitebark pine communities in GLAC. Sampling will be stratified to represent the topo-climatic gradient in the Park. Data will be gathered using ECODATA techniques (Keane et al., in press, Keane et al. 1990, Hann et al. 1989). Information will be collected along transects and in 0.10 ac circular plots on stand structure, fire history, fuels and plant community composition. Age, size and health of all trees > 2 cm dbh will be determined. Fire history will be determined from tree age and fire scars. Dead, down woody fuels and organic material will be inventoried about the macroplot (Brown 1974). Plot centers will be located with a global positioning system (GPS).

Blister rust severity will be evaluated for each whitebark pine tree by ocular estimation of 1) number of cankers visible from the ground, 2) number of infected trees within the plot, and 3) proportion of tree foliage killed by rust. Mountain pine beetle (*Dendroctonus ponderosae*) damage will be noted for each live and dead whitebark pine tree. When evidence exists, cause of mortality for dead trees will be estimated.

Monitoring

Blister Rust Surveys: YELL has 88,500 ha (218,700 ac) of whitebark pine habitat. Geographically extensive surveys of whitebark pine stands for rust infection levels will be conducted in YELL and GRTE using Hoff's (1992) methods. Along trail segments and other transects, all seedlings (<6 in dbh) and mature (>6 in dbh), standing whitebark pine trees will be examined within 6 ft and 20 ft, respectively, of each side of the trail. Transects will be long enough to survey a minimum of 100 individuals in each age class . The number of trees in each of the following classes will be recorded: blister rust free, flagged branches/cankers present, dead top, dead from rust, dead from unknown causes. In highly infected stands in GLAC, apparently rust-resistant phenotypes will be marked with a metal tag and located with a GPS.

Monitoring Network: Permanent plots will be established in GLAC, GRTE, and YELL for monitoring whitebark pine status. The monitoring network will sample the topo-climatic gradient present in the whitebark pine zone. It will include a subset of the plots established in GLAC during field sampling for the mapping project and will use the same ECODATA methods to collect ecological information at each site. New plots will be located to represent the geographic extent of whitebark pine communities in GRTE and YELL. Some plots in YELL will be placed at cone monitoring sites. Plot centers will be marked with a metal stake and the location will be determined by a GPS.

Milestones

Complete survey and establishment of monitoring network in GRTE and YELL Sept.30, 1995.
Complete vegetation sampling and monitoring network in GLAC Sept.30, 1996.
Complete data entry Jan.31, 1997.
Complete final report and maps September 30, 1997.

Products

Digital whitebark pine community map for GLAC with whitebark pine mortality isopleths.
Baseline data to monitor trends of whitebark pine communities across topo-climatic gradient in GLAC, GRTE, and YELL.
Report describing whitebark pine cover types, status, trends and location of rust-resistant individuals.

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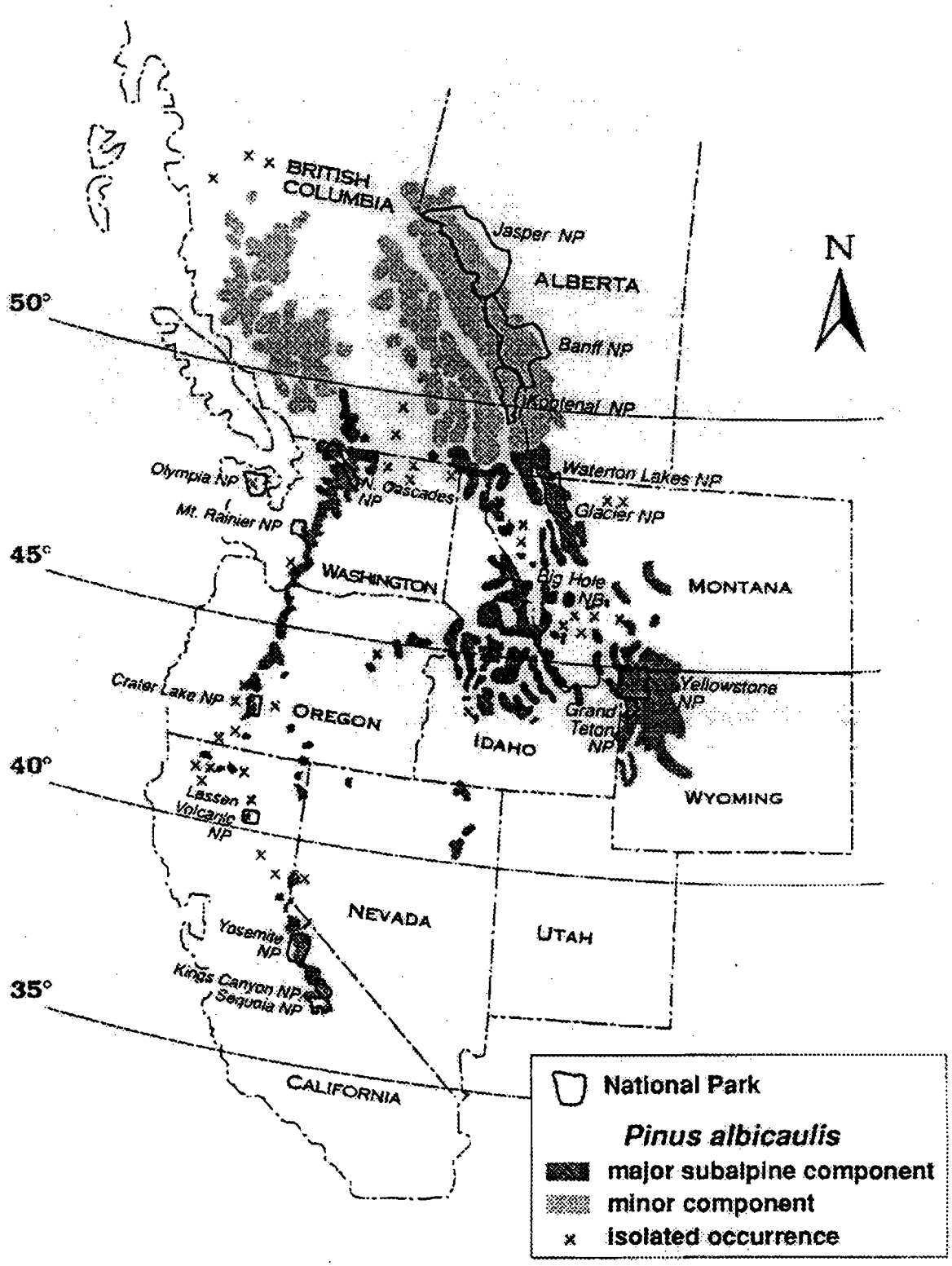
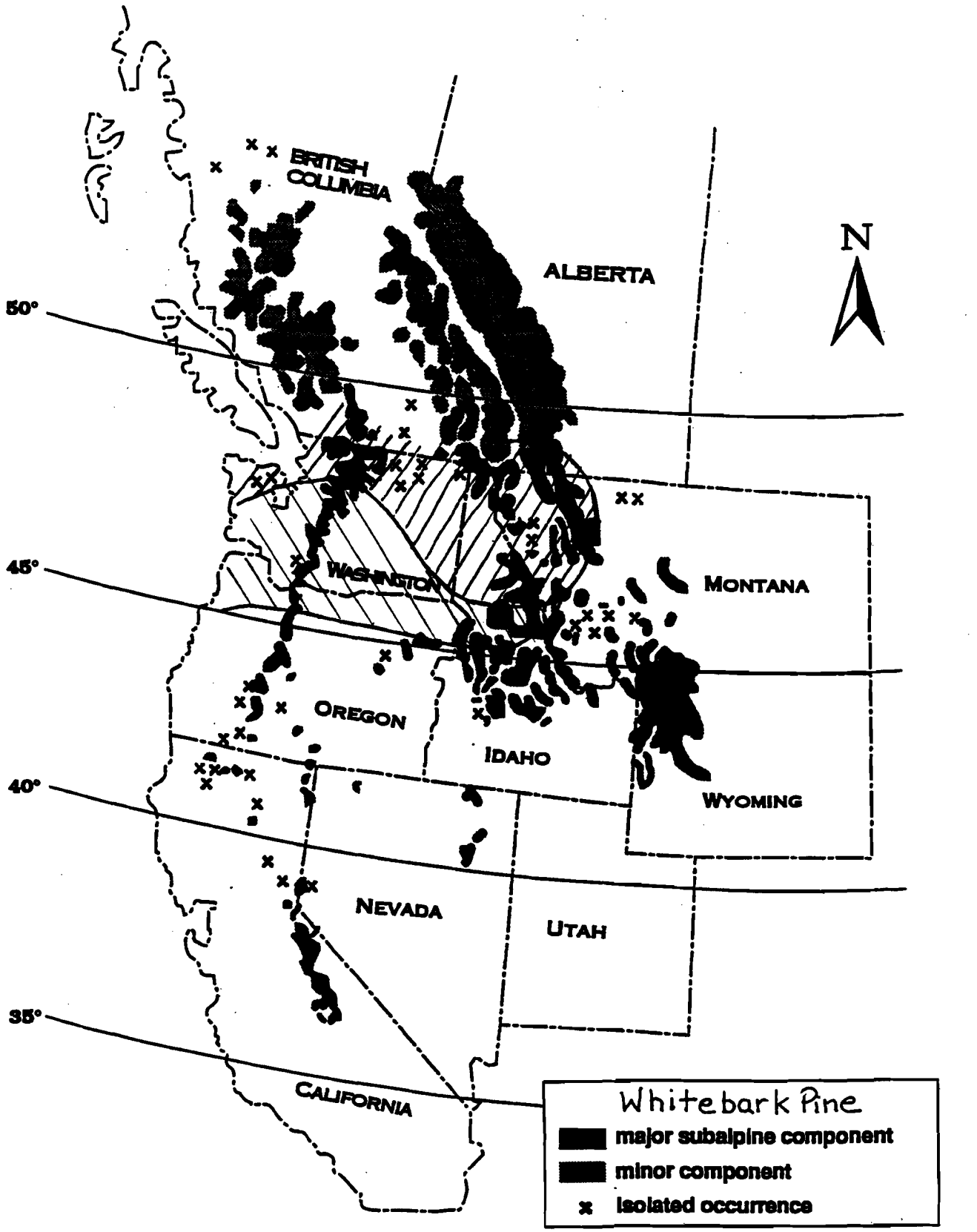


Figure 1. Map of Whitebark Pine range.



Whitebark Pine Mortality

50 - 100 % dead

20 - 50 % dead

0 - 20 % dead

Fig. 2

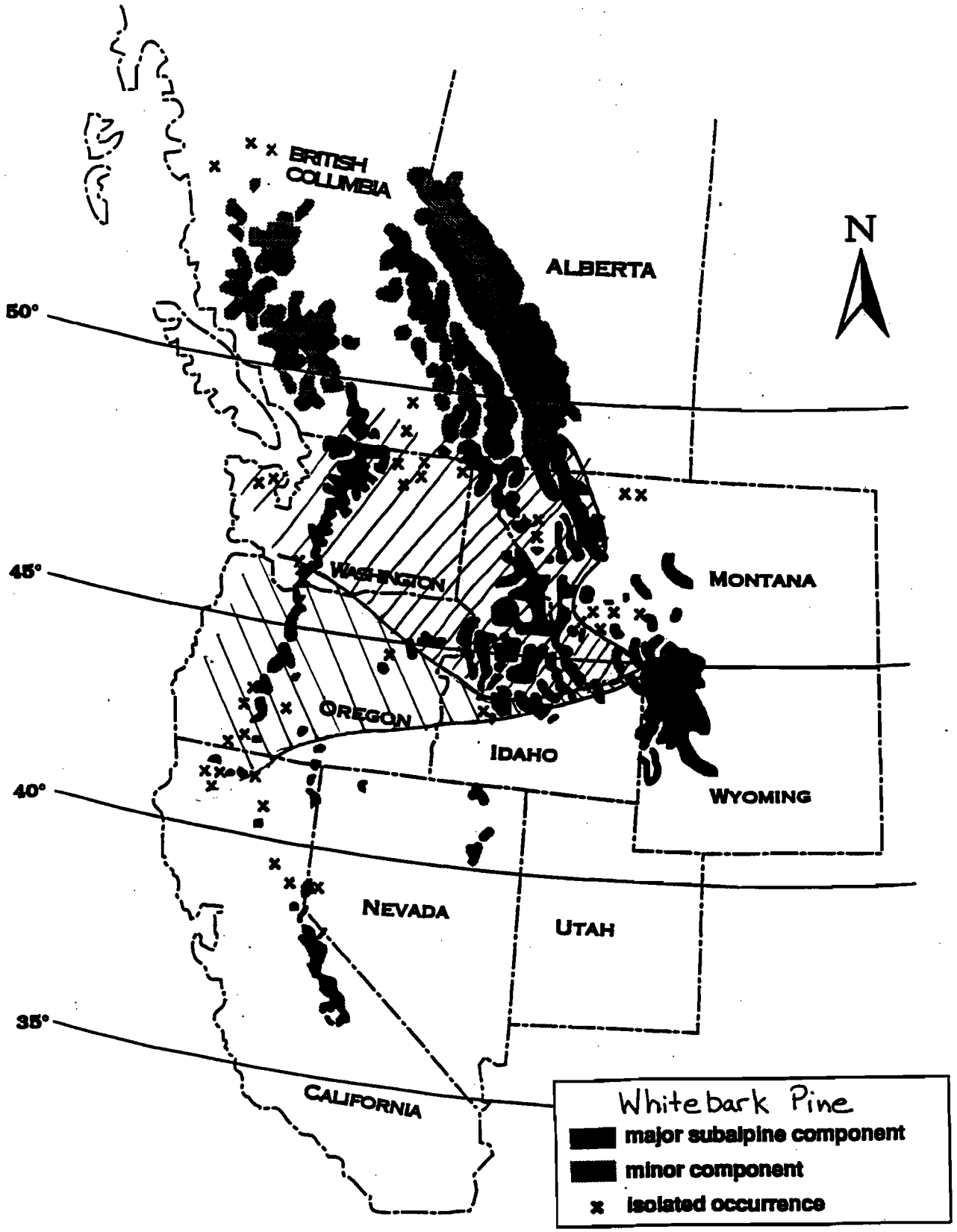


Fig. 3

Whitebark Pine Infected with Blister Rust

50 - 100 %

20 - 50 %

* Blister rust present but infection rate unknown for rest of range.

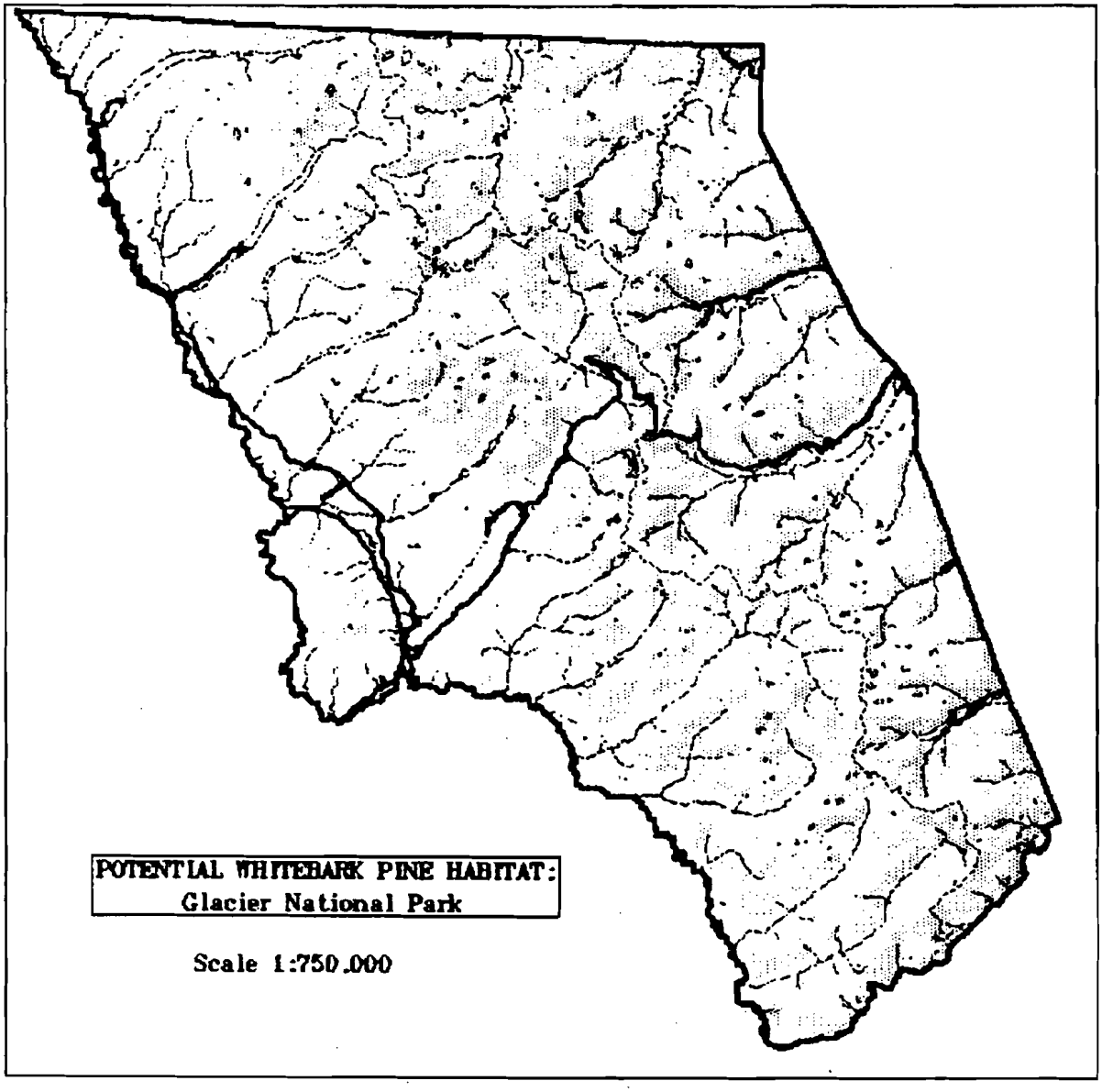


Figure 4. Map of potential Whitebark Pine habitat in Glacier National Park.

Table 1. U.S. National Park Service areas with 5-needle pines.

	PIAL whitebark	PIAR bristlecone	PIBA foxtail	PIFL limber	PILA sugar	PIMO w. white	PIST e. white
Acadia NP, ME							•
Allegheny Portage RR NHS, PA							•
Apostle Islands NL, WI							•
Bandelier NM, NM				•			
Big Hole NB, MT	•						
Big South Fork NRA, TN							•
Bighorn Canyon NRA, MT				•			
Blue Ridge Pkwy, NC							•
Bryce Canyon NP, UT		•		•			
Capitol Reef NP, UT		•		•			
Catoctin Mountain Park, MD							•
Cedar Breaks NM, UT		•		•			
Chickamauga & Chattanooga NMP, GA							•
Coulee Dam NRA, WA						•	
Crater Lake NP, OR	•				•	•	
Craters of the Moon NM, ID				•			
Cuyahoga Valley NRA, OH							•
Death Valley NM, CA		•		•			
Delaware Water Gap NRA, PA							•
Effigy Mounds NM, IA							•
Florissant Fossil Beds NM, CO		•		•			
Fort Donelson NB, TN							•
Fossil Butte NM, WY				•			
Gateway NRA, NY							•
Glacier NP, MT	•			•		•	
Grand Teton NP, WY	•			•			
Great Basin NP, NV		•		•			
Great Sand Dunes NM, CO				•			
Great Smoky Mountains NP, TN							•
Indiana Dunes NL, IN							•
Isle Royal NP, MI							•
Johnstown Flood NMEM, PA							•
Lassen Volcanic NP, CA	•				•	•	
Lava Beds NM, CA					•	•	
Mammoth Cave NP, KY							•
Manassas NBP, VA							•
Morristown NHP, NJ							•
Mount Rainier NP, WA	•					•	
New River Gorge NR, WV							•
North Cascades NP, WA	•					•	
Obed Wild & Scenic River, TN							•
Olympic NP, WA	•					•	
Pictured Rocks NL, MI							•
Rock Creek Park, Washington, D.C.							•
Rocky Mountain NP, CO				•			
Saratoga NHP, NY							•
Sequoia-Kings Canyon NP, CA	•		•	•	•	•	
Shenandoah NP, VA							•
Sleeping Bear Dunes NL, MI							•
Sunset Crater Volcano NM, AZ				•			
Timpanogos Cave NM, UT				•			
Valley Forge NHP, PA							•
Voyageurs NP, MN							•
Whiskeytown-Shasta-Trinity NRA, CA					•		
Yellowstone NP, WY	•			•			
Yosemite NP, CA	•				•	•	
TOTAL 56	11	6	1	18	6	10	28

Table 2. Status of whitebark pine (PIAL[3]) in North American national park areas.

Park Area	Veg. map?	Area with PIAL	Blister Rust? Absent/Present/Unknown	PIAL status
UNITED STATES				
Big Hole NB	N	PIAL rare	A[4]	unknown
Crater Lake NP	Y	unknown	P	>45% mortality[5]: 47% infection; 5% mortality[6]
Glacier NP	Y	unknown	P	>90% mortality[7]
Grand Teton NP	Y	unknown	U PIAL, PIFL[1]	low mortality
Lassen Volcanic NP	Y	unknown	P PILA, PIMO[1]; U PIAL	low mortality
Mount Rainier NP	Y	unknown	P PIMO, PIAL	Blister rust/mature PIAL: 95% infection; 25% dead[8]
North Cascades NP	Y	3,922 ha[9]	U	unknown
Olympic NP	N	unknown	P PIMO; U PIAL	poor reproduction
Sequoia-Kings Canyon NP	Y	unknown	P PIBA[1], PILA, PIMO	healthy
Yellowstone NP	Y	88,500 ha[10]	U PIAL, PIFL	low mortality PIAL
Yosemite NP	Y	12,727 ha[11]	P PILA; A[2] PIAL, PIMO	healthy
CANADA				
Banff NP	Y	300 ha	U	unknown
Jasper NP	Y	57,730 ha	U	no apparent threats
Kootenay NP	Y	unknown	U	unknown
Waterton Lakes NP	Y	3,990 ha	P PIAL, PIFL	serious mortality; extent unknown

[3] PIAL = *Pinus albicaulis*; PIBA = *P. balfouriana*; PIFL = *P. flexilis*; PILA = *P. lambertiana*; PIMO = *P. monticola*.

[4] Absence assumed but no surveys conducted.

[5] From Jackson and Faller (1973).

[6] Figure from survey from Lodge to Discovery Pt. on 16 July 1992 (Hoff 1992).

[7] From Kendall and Arno (1990).

[8] Figures from survey of Sunrise Ridge Trail on 10 August 1992 (Hoff 1992).

[9] From Agee and others (1985).

[10] From Renkin and Despain (1992).

[11] From Jan Van Wagtendonk (1992).

Notes

WHITEBARK PINE AND ECOSYSTEM MANAGEMENT: AN ECOLOGICAL PERSPECTIVE

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ABSTRACT

The basic goal of ecosystem management is to manage the land to meet society's needs and values in a manner that is sustainable. The art and science of ecosystem management is based on several key principles. The first principle is that an area must be assessed and managed in the context of the broader system. This applies to our human societies needs and values, as well as other biological and physical attributes of ecosystems. A second key principle is that we understand the function and inter-relationships of ecosystem attributes that we are managing. The third principle is that we conserve native ecosystem processes and attributes. These principles are not new in natural resource management. In fact, they are thoroughly discussed in "lay persons" language in "Sand County Almanac" by Aldo Leopold. Recently these principles of ecosystem management have been addressed in a thorough scientific summary, with application examples, in the Eastside Forest Ecosystem Health Assessment Volume II, which is being published by the Pacific Northwest Station of the Forest Service.

This should provide a background for discussion of the importance of the whitebark pine ecosystems in ecosystem management. This high-elevation ecosystem provides excellent examples relating to the principles of ecosystem management. The whitebark pine ecosystem is typically at the headwaters of hydrologic systems, and whitebark pine itself provides important functions in snow-pack retention, soil development, transpiration, habitat, and buffering other species from extreme weather events such as high winds and growing-season frosts. This ecosystem is connected to adjacent lower elevation systems by fire, insect, disease, and animal-use processes. Adaptations of whitebark pine are similar to other stone pines around the world in high stress environments. Stone pines have provided an important food source for humans, as well as other animals. These ecosystems are also valued by humans as places with high aesthetic and spiritual value. Understanding the broader context of whitebark pine and its connected ecosystems at the global, continental, and river basin scales will help us prioritize and develop management treatments that provide sustainable values and uses for society from this ecosystem.

The whitebark pine ecosystem provides a very interesting example of the function and connection of ecosystem processes and attributes. The complex linkage of fire, Clark's nutcracker, and site conditions needed for whitebark pine regeneration is an superb laboratory for scientific study and a classroom for ecosystem education. The relationship that whitebark pine has with regeneration of other tree

species, succession of nonforest species, and amelioration of the severe environments at timberline are exemplary to the need to manage for ecosystem sustainability rather single resource or species management.

Managing for recovery of whitebark pine in light of its steep decline, due to the policies that have excluded the "natural" fire process and introduction of white pine blister rust, provides an meaningful example of the need to conserve "all the pieces" as well as avoid introduction of non-native species. This ecosystem also provides sound evidence that single species (fine filter) conservation strategies, that are not taken in context of spatial and temporal ecosystem processes or attributes (coarse filter), will not only be unsuccessful in recovery of the target species, but may lead to loss or disfunction of other ecosystem processes or attributes.

There seems to be consistent agreement between scientists and resource managers that we must take an active approach in conserving this ecosystem. A protection or leave-it-alone strategy will not succeed in maintaining this high-mountain resource on the subalpine landscape. The natural process of fire that promotes and maintains whitebark pine's dominance on the landscape is currently in conflict with our policies of fire exclusion. The exotic blister rust is working to accelerate the successional replacement of whitebark pine with subalpine fir. Silvicultural opportunities for maintenance of whitebark pine are limited because of site fragility, inaccessibility and economic constraints. Use of manager-ignited prescribed fires, release cuttings to favor whitebark pine regeneration, and aiding the propagation of natural resistance to blister rust in whitebark pine populations seem to be the most obvious alternatives (Arno per. comm.).

Society is and will continue to pay a high price for the loss of whitebark pine in these ecosystems. If society determines that whitebark pine is worth the price of recovery, then the long-term cost will be the least if we start soon and design recovery strategies in the context of the broader system. Scientists and managers that have taken a leadership role in improving our understanding and initiating recovery of whitebark pine based on ecosystem principles, should be rewarded for their progressive efforts in management of this valuable resource.

Notes

THE APPLICATION OF AERIAL SKETCHMAPPING SURVEYS AS AN INVENTORY TOOL AT THE LANDSCAPE LEVEL IN WHITEBARK PINE ECOSYSTEMS

A PILOT PROJECT

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THE QUESTION

Is it possible to produce a reliable, timely, cost effective map to help land managers assess whitebark pine (WBP) conditions at the landscape level using aerial sketchmapping techniques? Forest Pest Management specialists annually fly 300 to 400 hours each summer sketchmapping the effects of insects and diseases in forest ecosystems. An attempt was made in late September 1993 to use these methods and apply them to the cumulative effects of insects and diseases to mature WBP.

BACKGROUND

In a time of reduced budgets, reduced timber management activities, and at a time of greater emphasis on Ecosystem Management, wildlife habitat and standing back to look at the forest at the landscape level rather than at the timber stand level, the need for new, efficient and cost effective inventory methods in the long ignored WBP type has become necessary.

PROJECT AREA

This survey was done on the Glacier View Ranger District, Flathead National Forest, in northwest Montana, just south of the Canadian border and just west of Glacier National Park. The area surveyed included most forested areas above 5800 feet elevation, covering approximately 100,000 acres.

THE AERIAL SURVEY

Prior to the survey flight, a ground visit to the area was done to look at a variety of WBP stand conditions. As in any type of remote sensing, on site ground work improves the delineation and coding of polygons.

The following condition classes were proposed to indicate WBP conditions:

LIVE TREES	PER CENT OF DEAD WBP
1. Mature WBP in mixed conifer	_____
2. Seed/sapling/pole (mostly WBP)	_____
3. Pure (>75% mature WBP)	_____
4. Young mixed conifer, seed/sapling/pole	_____
5. Pure scattered WBP	_____
6. Patches of dense WBP	_____
7. Forested, but no WBP visible	_____

In addition to coding the live condition classes, the per cent of old dead WBP was included as part of the polygon rating code. For example, if an area appeared to be mature WBP in mixed conifer, with approximately forty per cent of the WBP dead, the area was delineated into a polygon and coded "1D4". Much of the entire area was coded "1", and then various amounts of old dead were included in the code. This rating system helped provide an indicator of where live mature WBP were located, as well as where high mortality in WBP had occurred.

To make the determination from the air, it proved most effective to have two observers on the same side of the aircraft. The front seat observer navigated and sketchmapped. The back seat observer used field glasses to get a closer look and photographed different condition classes. Using an intercom system in the aircraft, the two observers could easily communicate and discuss various condition classes of the area below, in order to calibrate and validate what the front seat observer was mapping. There is no doubt that the sketchmapping experience of the front seat observer and the on site experience in WBP of the back seat observer made for a much more effective survey.

The survey was done at an altitude of approximately 1000 to 2000 feet above ground level. Most of the area surveyed occurred on the ridge tops. The aircraft's airspeed was between 85 and 110 miles per hour. Flight time for the actual survey was eight hours at a cost of $134.00 per hour. Some areas were flown more than once to give the observers a better view or for the need to discuss condition class ratings. Because the survey was flown so late in the season, the low sun angle did not provide north facing steep slopes adequate sunlight to make an acceptable condition determination.

Working maps for the survey were 1:24,000 USGS topography maps. Several maps were taped together to cover specific areas and the project area was drawn on the maps prior to the survey. The working map polygons were then transferred to a master 1:24,000 USGS maps for a final copy to be used for input into the geographic information system and archives.

POST FLIGHT MAP ANALYSIS AND MAP PROCESSING

Map polygons were checked against timber stand exam records that were available in some of the areas surveyed. Some specific site visits were conducted prior to winter snow fall. Comparing ground data to aerial map data provided a relatively comfortable acceptance of the map data.

The sketchmap polygons were digitized into JELLY and converted into SPATIAL at the Forest Pest Management office in Missoula. Data summaries and a color coded map was plotted to show conditions over the entire area.

RESULTS

Because little information is available on conditions of WBP in many management areas, most any new information is welcome. Because of the high costs of ground inventory data and the low priority of "low timber value areas", the ability of land managers to collect information is, at the least, challenging. Using aerial sketchmapping as a broadscale inventory tool for WBP areas was a low cost, quick method of gaining new information and insights into the conditions of WBP.

Several original condition classes were not used because of the difficulty in making calls from the aircraft. Primary clues were live and dead mature WBP. No cause of death determinations of WBP were made from the air.

After comparing mapped polygons condition classes with previously collected ground data, the sketchmapped polygons showed a relatively high degree of accuracy. The resolution of this inventory method is much more acceptable at the landscape level, rather than at the stand level. It must be understood that the map was created from an airplane in a short amount of time. So there are limits with this method, but it is still good information at a time when little information is available. Participants in this project consider the answer to the original question is "yes".

Notes

WHITEBARK PINE INFORMATION SURVEY RESULTS
USDA FOREST SERVICE, REGION 6

Presented by Joe Linn

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ABSTRACT
In December, 1993, we distributed a questionnaire asking for information on the condition of whitebark pine in the Pacific Northwest Region. Whitebark pine is an important component of forest ecosystems in the higher elevations in the Region and recently, concerns have been raised regarding the viability of the species in some parts of its range because of the tree's susceptibility to white pine blister rust, insect attack, and changes in fire ecology.

The questionnaire was well distributed and reached a good cross section of personnel working in ecosystems containing whitebark pine. We received more than 60 responses from all of the national forests and regional office staff units as well as national parks in Region 6. Those responding included foresters, resource technicians, and specialists such as ecologists, botanists, geneticists, entomologists, pathologists, wildlife biologists, archaeologists, historians, and those involved with fire, recreation, timber, silviculture, and special uses. We thank all of you who responded with your input.

In summarizing these responses, several issues appeared again and again as specific areas of interest where more information was needed. These include inventory, ecology of the species, insect and disease damage surveys, cultural and sociological needs, and genetics. Whitebark pine is found in high elevation landscapes on national forest, national park and indian reservation land throughout the Pacific Northwest with the exception of the Ochoco and Siuslaw National Forests. Much of the whitebark pine is located in wilderness areas, but some occupy high elevation land outside of wilderness and roadless areas. Whitebark pine is reported to be healthy in south central Oregon. There are no unusual problems with the species in central, southern and southwest Oregon.

There seems to be good interest and a spirit of cooperation amongst the National Forest and National Parks in learning more about whitebark pine; there is concern for the species but a lack of information about the distribution, location, and severity of damage to the species in many areas. The region has experience in surveying blister rust disease and bark beetle activities and has extensive experience with rust screening, determining seed zone delineations, and examining other questions regarding pest management, genetic variability and conservation.

A small regional task group will meet in the next month to plan regional strategy for potential activities dealing with whitebark pine. We will consider ways for cooperating with the National Parks and other agencies or organizations interested in whitebark pine and will consider the merits of conducting local workshops, organizing field surveys and doing range-wide studies.

A more complete summary of the survey follows.

SUMMARY OF COMMENTS TO WHITE BARK PINE SURVEY

A whitebark pine (*Pinus albicaulis*) survey for Oregon and Washington was initiated in December 1993. Input was sought on all aspects of whitebark pine ecology and management. Due to the preliminary nature of this survey, responses were requested by January 21. Comments were received from many areas in Oregon and Washington. Although not comprehensive, this survey gives a valuable overview on the general status of the species, its importance, and the general lack of knowledge about it, as well as a list of contact persons (mailing list as a starting point for further information). This type of survey could be useful for gathering quick, initial responses on other species or other topics, however, to be effective, a good network of contacts must be reached, a deadline for information must be established, the written request for information short be short, and a small core team should be established to facilitate collecting and summarizing responses. Below is a summary of responses and some additional resource information.

Survey Needs

* OLY - Olympic National Forest/Ecologist - WBP rare on park and forest, some in Buckhorn Wilderness, survey needed.

* N. Cascades National Park - map park next year. Include WBP, desire to collaborate and participate in a survey, will be hiring an ecologist.

* Olympic National Park - park very interested, concerned by obvious mortality, desire cooperative work.

* Mt. Rainier National Park - plan survey this year - want to collaborate, found no infection on a trail, was told of trail rim survey that showed 92% infection, 45% mortality.

* UMA - Silviculturist - limited distribution on Forest, primarily on south end of Forest, south of Olive Lake. Occurs on serpentine soils, high elevation in krummholz form. Most WBP in North Fork John Day Wilderness, Vinegar Hill - Indian Rock Scenic Area. Botanist did not notice any significant pest problems. Concerned about species, important for several bird species. Interested in any follow-up survey.

Disturbance Agents

* OLY - Contractor - old WBP dying of climate change (comment).

* Olympic National Park - park very interested, concerned by obvious mortality, desire cooperative work.

* Mt. Rainier National Park - plan survey this year - want to collaborate, found no infection on a trail, was told of trail rim survey that showed 92% infection, 45% mortality.

* UofW - National biological survey - doubts if mortality is as great as initial feedback of survey, has experience with WBP.

* COL - Logging Specialist - health of WBP generally poor, declining in vigor, being replaced by other tree species in every stand observed in reconnaissance. Problem - rust and beetles. Regeneration over 4 feet tall shows rust.

* WEN - Botanist - rust is a major problem in WBP in most of N.E. Washington, concern about changes in community type taking place because of rust. Remembers Colville National Forest having numerous ghost forests of WBP as a result of fire and rust. Suggests consulting with Steve Arno, an expert.

* GIP - Geneticist - WBP scattered around Mt. Adams, blister rust incidence very low even though alternate host, Ribes spp., are present.. Possibly Atropellus cankers in mixed stands with lodgepole pine. Some very large trees on Yakima Indian Reservation and they may have interest.

* DES - Pathologist, Entomologist, Resource Specialist, Fire Management, summary of 1991 site visit to Crater Lake National Park - visited 4 sites. Mortality along trail result of blister rust - 5% dead from rust, many more exhibiting flagging of single branches (which have died). Beetle causing major damage along trail, some scattered rust. Mortality slightly above endemic.
  * Discussed understory burning results, less than desirable, had hoped to reduce competition.
  * Beetle killed pine on Wizard Island.
  * Mountain pine beetle kills WBP sporadically and its dynamics are less dramatic than in other pine hosts.

* WAW - Genetics, Silviculture - occurs at high elevations in both Wallowa Mountains and Elkhorns. Isolated populations may be of interest from genetics standpoint. Some pest problems but mainly unknown. Some rust, beetles. Pathologist interested in field visits to confirm.

* COL - Ecologist - Colville has 6 full classification plots, 24 recon plots in WBP. WBP has been devastated in the past few decades. Blister rust has run rampant, beetles also contributing to mortality. Unusual to find high elevation subalpine stands still dominated by WBP. Need rust resistant stock. Have site data, can query vegetation data.

* WEN - Silviculturist - (1969 published statistics) 1229 acres of WBP type on Wenatchee. 1/4 of it was burned over in 1970 fires. Lot of mortality from rust and beetles to individual trees but stands are intact. Reproduction in openings common from seed sources higher in elevation. 1993 aerial survey - no areas of mortality to WBP.

* RO - Recreation, wilderness - concern over management of WBP with regard to wilderness policies. Hopeful of restoring natural fire regimes in wilderness areas which may aid in WBP restoration. Cone collections possible in wilderness, if done properly.

Eco-Plots

* COL - Ecologist - Colville has 6 full classification plots, 24 recon plots in WBP. WBP has been devastated in the past few decades. Blister rust has run rampant, beetles also contributing to mortality. Unusual to find high elevation subalpine stands still dominated by WBP. Need rust resistant stock. Have site data, can query vegetation data.

* CONF - Ecologist - started an age/stand structure study in the Warner Mountains. May put together "state of the art" paper on biology and management of PIAL.

* CONF - Species has generally been overlooked because it is noncommercial and/or mostly in wilderness.

* WEN - Botanist - rust is a major problem in WBP in most of N.E. Washington, concern about changes in community type taking place because of rust. Remembers Colville National Forest having numerous ghost forests of WBP as a result of fire and rust. Suggests consulting with Steve Arno, an expert.

* WIL - Forest Supervisor, Silviculturist, Geneticist and Ecologist - WBP minor component along Cascade crest, little known. Some ecology plot data collected - Mt. Jefferson Wilderness and Three Sisters Wilderness. Spot check plots this year, collect seed for genetic conservation. Desire to begin testing

for rust resistance. Will assess site hazards. Would like a provenance test to evaluate the species range, should collect seed before lose some populations. Attached data from ecoplots. Concern that species is disappearing from some areas and that not enough trees will be left to effectively regenerate.

Genetics

* COL - Ecologist - Colville has 6 full classification plots, 24 recon plots in WBP. WBP has been devastated in the past few decades. Blister rust has run rampant, beetles also contributing to mortality. Unusual to find high elevation subalpine stands still dominated by WBP. Need rust resistant stock. Have site data, can query vegetation data.

* NWNF - Geneticist- Interest in this area in whitebark pine (PIAL) is high, funding of activities is an issue, meeting on PIAL would probably be well attended.

* NWNF - Olympic & MBS National Forest Ecologist - Concern about loss of WBP on both forests, asked if we started rust resistance program. Describes specific area in Buckhorn Wilderness - extensive mortality in crowns.

* WIL - Forest Supervisor, Silviculturist, Geneticist and Ecologist - WBP minor component along Cascade crest, little known. Some ecology plot data collected - Mt. Jefferson Wilderness and Three Sisters Wilderness. Spot check plots this year, collect seed for genetic conservation. Desire to begin testing for rust resistance. Will assess site hazards. Would like a provenance test to evaluate the species range, should collect seed before lose some populations. Attached data from ecoplots. Concern that species is disappearing from some areas and that not enough trees will be left to effectively regenerate.

* WIN - Genetic Resources - Klamath Falls District plans to include PIAL in its genetic resource program and hoping to do isozyme analysis testing in 94 to examine genetic diversity. Little known about overall health of WBP on the Forest, but could gather some information while making seed collections.

* WAW - Genetics, Silviculture - occurs at high elevations in both Wallowa Mountains and Elkhorns. Isolated populations may be of interest from genetics standpoint. Some pest problems but mainly unknown. Some rust, beetles. Pathologist interested in field visits to confirm.

Inventory

* WEN - Silviculturist - (1969 published statistics) 1229 acres of WBP type on Wenatchee. 1/4 of it was burned over in 1970 fires. Lot of mortality from rust and beetles to individual trees but stands are intact. Reproduction in openings common from seed sources higher in elevation. 1993 aerial survey - no areas of mortality to WBP.

* UW Graduate Student (Bob van Pelt) - nice grove of very large trees SE of Mt. Stuart where tallest is 90'.

* GIP - Gathered pine nuts traditionally (Avalanche Valley). WBP populations were larger but have been reduced by insects according to one source. WBP hedges on north side of Mt. Adams, some in Goat Rocks and William O. Douglas Wilderness.

* GIP - Silviculture, Science, WBP on Mt. St. Helens National Volcanic Monument, (s.w. side) Butte Camp and French Butte.

* MTH - Silviculturist - describes WBP and impact by Mt. Hood Meadows Ski Area. Concern by archeologist for area used traditionally by Native Indians for nut collection.

* UMP - Recreation - WBP in Rogue/Umpqua Wilderness along Snowbird Road 2715. A lot of WBP are dying but uncertain why. Some regeneration occurring. Will look closely next year.

* ROR - Historian/Archeologist - Suggest using historic photograph collection from lookouts (back to 1911) to look for WBP. Some photos have reference to WBP written on back.

* ROR - Silviculturist - Evaluated WBP stocking in ski run on Mt. Ashland. Noticed clumps of WBP, cones, but no mention of rust or insect damage.

* ROR - Botanist - observes WBP in S. Oregon, species does not appear to be in any trouble, some lack of recruitment but not unusual.

* DES - Genetic Resources - Little known about WBP on the Deschutes National Forest. WBP included in current inventory. Some WBP on south boundary of the Forest, some in wilderness on north end. Seem to be different in appearance than WBP on the Fremont National Forest. Some stand exam data on one area that contains WBP, some blister rust.

* FRE - Reforestation, GIS - several pockets WBP on Forest. No known rust, mainly due to dry climate. Tried seed collections but were unsuccessful to date (animals got there first). Healthy WBP in Green Mountains and Gearhart Wilderness, regeneration occurring in some areas. Clark's Nutcracker present.

* MAL - Some WBP in Scenic Area, impression is that WBP is ok (at least in this area), fire exclusion might cause problems.

* WAW - No formal surveys, observations reveal widespread rust problem in the Wallowa Mountains, severity varies, may also be limber pine.

Wildlife

* OKA - Silviculturist, Wildlife Biologist - precommercial thinning treatment to favor WBP in N. Cascades Grizzly Bear Recovery Area using T&E habitat improvement funding. Manage to stimulate WBP to produce cones - food source. Increase growth and vigor of WBP is effective method to manage for cone production, and increase the food base for grizzly and black bears, Clark's Nutcrackers, red squirrels, etc.. (Reference: McCaughey and Schmidt, 1990, GTR-INT-270). Insect and disease epidemics and fire suppression are leading to less PIAL in area. Twisp District is considering a comprehensive WBP survey. Winthrop Ranger District - WBP managed for potential wildlife forage, some are severely infected with rust. Overall impact of rust unknown.

* UMA - Silviculturist - limited distribution on Forest, primarily on south end of Forest, south of Olive Lake. Occurs on serpentine soils, high elevation in krummholz form. Most WBP in North Fork John Day Wilderness, Vinegar Hill - Indian Rock Scenic Area. Botanist did not notice any significant pest problems. Concerned about species, important for several bird species. Interested in any follow-up survey.

Recreation/Wilderness/Heritage Resources

* MTH - Archeologist - cultural/N. American traditional use, concern for WBP. 2 areas contain WBP on Mt. Hood - Cloud Cap/Tilly Jane Historic District on N.E. side, was told of trees dying - unknown cause.

* MTH - Recreation, Special Uses Admin. - cannot assess the relative health of existing stands - described impacts of ski area on WBP. Assistant Forest Ecologist - mapped out WBP and used plot information to assess ski area.
  Summary - WBP trees have been impacted by ski hill development. Can revegetate disturbed ground with WBP.

* MTH - Mt. Hood Wilderness - unknown assessment - Timberline Trail is located in WBP zone.

* MTH - Warm Springs Indian Reservation - Indians use to collect pine nuts in ski permit areas. Pine nuts produced every 5-7 years. Indians asked that we preserve resource of WBP. Tried planting WBP but doesn't appear successful, desire to restore species.

* RO - Recreation, wilderness - concern over management of WBP with regard to wilderness policies. Hopeful of restoring natural fire regimes in wilderness areas which may aid in WBP restoration. Cone collections possible in wilderness, if done properly.

Notes

PRECOMMERCIAL THINNING TO FAVOR WHITEBARK PINE ON THE TWISP RANGER DISTRICT, OKANOGAN NATIONAL FOREST

Presented by John Rohrer

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ABSTRACT

Introduction

The Okanogan National Forest is on the east side of the North Cascades Mountain Range and within the recently designated North Cascades Grizzly Bear Recovery Zone. Whitebark pine occurs at elevations above 6000 feet and may be an important food source for grizzly bears in the North Cascades. Insect and disease epidemics and successional replacement threatens whitebark pine stands here as well as throughout the intermountain west. In young, mixed-species stands, fire suppression has favored shade-tolerant species such as subalpine fir and contributed to the severity and risk of disease epidemics.

Many wildlife species forage whitebark pine seeds directly from the trees, but, grizzly bears raid red squirrel middens where the seeds are cached. Red squirrels favor mixed-species stands with closed canopies. Managing whitebark pine silviculturally to produce cones is one method of maintaining this wildlife food source. Managing for pure, open-grown stands of cone-producing whitebark pine may be the most effective means of maintaining the species in an ecosystem. Managing young, mixed-species stands to increase growth and vigor of whitebark pine while maintaining other species may be an effective method to manage for both red squirrel habitat and cone-producing whitebark pine. It has been shown that well-spaced trees produce more seed and that effects of spacing are more pronounced in shade-intolerant species like whitebark pine. Spacing control can produce trees with a higher proportion of fully exposed crown which are more vigorous and likely to bear cones.

Project Description

The Foggy Dew project was a precommercial thinning treatment of one half of a 15 acre stand. No past management activities had occurred in the stand. The stand is located at 6440′ elevation on a northerly aspect along the upper third of the Middle Fork Ridge in the Foggy Dew drainage. The stand is composed primarily of whitebark pine (>50% based on trees per acre) in the sapling to small pole size classes. Stocking is variable, averaging 1,000 trees per acre in thickets to less than 100 trees per acre in naturally occurring openings. Other species

present include subalpine fir, Engelmann spruce, lodgepole pine, and subalpine larch. Douglas-fir and ponderosa pine were noted in the general vicinity, but not in the subject stand. The average age of the stand is approximately 40 years. Understory vegetation consists of seedling to sapling sized components of Engelmann spruce, subalpine fir, and lodgepole pine, with understory forbs and shrubs generally lacking. Ribes is present (near the ridgetop), however no incidents of blister rust were noted. Downed woody fuel loadings occur in jackpots well distributed throughout the stand.

General management direction from the Land and Resource Management Plan, Okanogan National Forest (12/89) is to provide recreational opportunities characterized by a predominately natural or natural appearing landscape. Stand management objectives are to promote individual tree vigor for crown development and cone production, increasing the food base for grizzly and black bears, Clark's Nutcrackers, red squirrels, and several other birds and mammals (McCaughey and Schmidt, 1990, GTR-INT-270).

Target stand conditions (Figure 1) were developed from target stand descriptions identified by Chew (Timber Management and Target Stands in the Whitebark Pine Zone, from Proceedings - Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource, June, 1990). They are a composite of conditions identified for lodgepole pine and Douglas-fir as whitebark pine is considered to exhibit silvical characteristics that indicate a moderate tolerance during later development stages (McCaughey and Schmidt, 1990). The target stand conditions identified therein were modified to reflect management objectives that are designed to develop stands where primary objectives are not related to timber management and grazing (McCaughey, pers.comm., 8/92).

Figure 1. Target Stand Conditions

Development Stage	Age	Trees per Acre	Basal Area
Sapling	20-40	350-1400	N/A
Pole	40-60	300-750	55-175
Immature	60-90	200-350	100-200
Mature	90-120	150-300	140-210

An alternative that allows a more conservative approach, which removes fewer trees during initial stocking control, provides for effectiveness monitoring, and recognizes the potential for further basal area management at a future date (possibly 20-40 years hence) was selected. This approach is favored because it will allow resource managers the opportunity to assess the success of the initial

treatment, and determine whether additional stocking level control will be needed to meet objectives for improving forage habitat. The stand management prescription scheduled a best tree thinning from below to an average of 450 trees per acre. Species in order of crop tree preference and stocking was whitebark pine (50%), Engelmann spruce (20%), subalpine fir (20%), and lodgepole pine/subalpine larch (10%).

Project Implementation

This treatment was accomplished with TE&S habitat improvement funding, by a crew of 5 in 3 days in September 1992. Monitoring plots were established in the thinned and unthinned portions of the stand. We are considering a comprehensive whitebark pine inventory of our district to identify management concerns and opportunities.

The Foggy Dew project was appealed by the Cascades Chapter of the Sierra Club. The appellants misinterpreted the project as a logging operation that was inappropriate, unnecessary, and inconsistent with the Forest Plan. The district decision was upheld as the stand management prescription was determined to be within Land and Resource Management Plan guidance.

Notes

MADISON RANGE ECOSYSTEM MANAGEMENT PROJECT

Presented by Julie Heff-Shea

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ABSTRACT

Last year, at the Whitebark Pine Workshop, we gave a presentation on the North Hebgen Ecosystem Management Project. Since that time the project has expanded into the Madison Range Ecosystem Management Project. This presentation is an overview of what we've done and where we are going.

The project is a collaborative effort of three federal agencies, one state agency, three universities and two Forest Service Regions. The proposal is in the heart of the Greater Yellowstone Area. It contains prime grizzly bear habitat, the Lee Metcalf Wilderness Area and a portion of Yellowstone National Park. We see this proposal as an excellent opportunity to implement ecosystem management across administrative boundaries and within an area which has complex resource and social issues.

The Madison Range Project is located in the Madison Mountain Range in southern Montana. It incorporates approximately 500,000 acres in Yellowstone National Park (14,000 acres), Beaverhead National Forest (200,000 acres) and the Gallatin National Forest (300,000 acres). Local communities adjacent to the project area are Bozeman, Ennis, Big Sky, and West Yellowstone, Montana. The area is bounded on the west by the Madison River, the south by Hebgen Lake, the east by the Gallatin River, and the north by Ted Turners Flying "D" ranch.

Project Objective

Identify broadscale management practices that address desired conditions, in the Madison Range, by December 31, 1994.

Project Principles

- Integration of Social, Economic and Ecological Factors
- Understanding Range of Natural Variability
- Multiple Scale Approach
- Public Involvement
- Collaboration
- Adaptive Management
- Conservation of Biodiversity
- Consideration of Ecological Functions

BACKGROUND

To understand where we are going it helps to understand where we have been.

The project was initiated in the winter of 1993 on approximately 200,000 acres. A project proposal was developed and sent to the USFS regional office for funding. Partial funding was received for the project in the spring of 1993. In May, we hosted a workshop for the Greater Yellowstone Coalition. The workshop was a real benefit to the project because we were introduced to a number of individuals doing similar work in the Greater Yellowstone Area. After the field trip, a post doctorate student informed me that she was doing a very similar study at Montana State University. This was the start of a strong partnership with the university.

Later in the spring, we hosted a meeting to determine ongoing ecosystem projects within the western edge of the Greater Yellowstone Area. This meeting started our partnership with the Targhee National Forest and brought in the Regional Office (R-1) into the project. We all agreed to meet in the summer discuss how to implement ecosystem management.

In June, of 1993, we hosted a two day meeting on implementing ecosystem management for the area. It was a very productive session that included 40 people from Forest Service Research, four universities, Yellowstone National Park, and two Forest Service Regions. This meeting initiated the involvement of the USFS Region 4 office. The meeting was also an opportunity to inform the West Yellowstone community of our activities. The meeting was attended by a local journalist who wrote a two page article in the newspaper.

In late summer, a District Ranger from the Beaverhead National Forest proposed to add part of that forest to the project. The landscape was enlarged to cover a portion of the Madison Ranger District (Beaverhead National Forest) and a portion of the Bozeman Ranger District (Gallatin National Forest). The landscape now was bounded more by ecological boundaries rather than by administrative boundaries.

OVERVIEW OF THE LANDSCAPE

This portion of the presentation is a video.

Buffalo

This is the eastern edge of the landscape; it's our Yellowstone National Park connection. We are currently participating in a partnership with Yellowstone National Park and Montana State University. The USFS has scanned and edited some spatial data while a park service employee is running the software on Montana State University hardware.

One of the issues in the Madison Range is that elk migrate between Yellowstone National Park, the Gallatin National Forest, the Beaverhead National Forest, and private land in the Madison valley. Montana State Fish, Wildlife and Parks is interested in working with this issue in part because it crosses administrative boundaries.

Spanish Peaks

This is the northern portion of the landscape; the Spanish Peaks section of the Lee Metcalf Wilderness Area. The area's lakes, streams, dispersed recreation sites, and trails are heavily impacted by many Bozeman residents; this is the most used section of the Lee Metcalf. On the northern edge of the landscape is Ted Turner's Flying "D" ranch.

Big Sky

This picture shows the tremendous growth potential smack dab in the middle of the landscape. Currently there are residential homes, mini malls, a large ski area and hundreds of condominium units throughout the valley. Private land owners have extensive plans for the development of this valley. Gallatin County has an active planning and zoning program that we will continue to participate in.

Ennis

This is a picture of Bette's Cafe, a landmark of western culture. Recently, this cafe was sold and will be converted into a coffee espresso bar; this reflects some of the culture change that is taking place in the community.

This picture shows a panoramic view of the Madison Valley. The majority of the valley is under private ownership. The Madison Ranger District has recently finished an ecosystem management project on the west side of the valley; we plan to utilize their public participation strategy as part of our ecosystem management process.

This is a picture of antelope in the Madison Valley. The antelope are grazing on the future site of the Lonesome Dove Ranchettes, the area has been

subdivided into 20 acre sections for residential development. All the development in the valley has a significant effect on the forested landscape. Prior to settlement, the alpine landscape was significantly altered by fires that started in the valley bottoms and worked their way up into the forest. The opportunity for such landscape change is now limited due to social desires.

Aspen

This is the southern end of the landscape. Mature aspen stands are scattered throughout the lower elevations. Management activities will no doubt focus on some of the aspen stands due to the large amount of conifer encroachment.

Douglas-fir

The southern aspects are dominated by Douglas-fir cover types. Prior to settlement, Native Americans probably burned the valleys which lead to frequent fires in the nearby forested areas. The frequent fires kept the Douglas-fir from encroaching on the unforested valley bottoms. As you can see, the Douglas-fir is encroaching into the valley where there are numerous residential homes.

Alpine-fir

At the middle to high elevations, alpine fir and lodgepole pine are the dominate cover types. Fire history analysis reveals periodic small ground fires and infrequent stand replacement fires.

Alpine Mosaic

The upper elevations are dominated by a mosaic of whitebark pine, subalpine fir, and mountain meadows. Wildfire followed by seed dissemination by Clark's nutcrackers may be the principal means by which whitebark pine becomes established. Suppression of wildfires may be having a significant effect on the distribution of whitebark pine.

Cabin Creek Basin

This picture shows the tremendous amount of mature timber stands. Is this a representation of post settlement landscape? Currently we are participating with the Targhee National Forest and Montana State University to characterize the landscape. Through a Targhee National Forest challenge cost share agreement the Gallatin and Beaverhead National Forests will provide the spatial data information to Montana State University. The university will complete the analysis with a software program called FRAGSTATS.

Taylor Fork Drainage

This drainage has five active range allotments. Range will be one of the issues we will be addressing.

Buck Creek

This drainage has a checkerboard ownership pattern. A significant amount of the private land has been logged. Most of the private land is part of the Gallatin Range Consolidation Proposal. Management activities will probably reflect watershed rehabilitation opportunities on the newly acquired land.

Albino Lake

A developer plans to subdivide his property adjacent to the lake. This is an example of the potential growth for the area.

PROCESS OVERVIEW

General Timeline

Basic Information	January - May (1994)
Natural Variation	March - May
Existing Condition	January - July
Desired Condition	May - October
Identify Management Practices	November
Wrap Up	December
Possible NEPA with No Forest Plan Amendments	January - May (1995)
Implementation	August

PUBLIC INVOLVEMENT

Somebody came up to me this year and wanted to discuss ecosystem management. The first thing that came to their mind was presettlement conditions, spatial and temporal analysis, and subregional assessments. The first thing that came to my mind was the faces of people, many different people. One memorable face was an eighty-one year old man. He walked into my office and positioned himself about two inches from my face. He proceeded to tell me how the Forest Service had just closed a road that he had used for the last six decades with his wife, relatives, friends, and grandchildren. The man was not trying to be disrespectful but wanted me to know how Forest Service actions had effected he and his family. I believe the decision to close the road was still correct but it sure makes me want to work hard at maintaining ecological integrity while meeting social desires. It seems that each week, our agency speaks to different people from various backgrounds with different resource/social concerns. I don't believe many agencies or organizations have the benefit of this diversity of social information.

It seems that the majority of people working in ecosystem management enjoy the biological analysis and shy away from the social aspects. We strongly believe that our process will require seventy percent or more of our efforts in the social arena.

Currently, we are developing a public involvement plan for the Madison Range Project. We are devoting a considerable amount of time to this plan because we feel it will be one of the foundations for the ecosystem management process.

COLLABORATION

Collaboration involves working with other agencies to facilitate land management decision making. We are very fortunate that the major agencies, associated with the Madison landscape, get along well. A good relationship with other agencies requires constant tending but can lead to additional expertise, cooperation, and resources. We have found that many people from the same agency think similarly while individuals from other agencies come with a different mindset. It is essential to have diverse viewpoints when developing an ecosystem strategy.

Collaboration can also help to cut down some of our organizational bureaucracy. It seems that when we have worked in partnership with other agencies that it is sometimes easier to figure out ways to cut through "red tape" (i.e. the Forest Service may have a limit on hiring but the Montana Fish, Wildlife, and Parks may not, the U.S. Fish and Wildlife Service may have a limit on housing but the Forest Service does not). Successful implementation of an ecosystem management strategy will be greatly increased if we can find non-traditional ways to get work done more efficiently.

INFORMATION MANAGEMENT

Information management is one of the keys to successful ecosystem management yet it is an incredibly detailed task. We have identified our basic information needs and are in the process of developing/updating our spatial and attribute files. This task has taken a tremendous amount of time, yet as we talk to other people who have worked on other projects they also find that considerable time is devoted to information management.

LEADERSHIP

Ecosystem management requires a substantial amount of leadership. We are fortunate to have a couple of rangers who are willing to lead. They spend a lot of their time supporting the process by planning ahead. They have committed people to IDT that are very independent thinkers, good listeners, and are more than willing to debate with anybody.

One of the primary factors that can help an EM effort is a Forest's Line Officer Group and Primary Staff. Is this group a management group or a leadership team? Are they preoccupied with putting out brushfires or spending time charting a

course for success? We have found that getting individuals involved with a specific task will help them find the time to lead rather than manage.

Our existing forest service organization resembles a bunch of stove pipes. Money and targets are funneled into hundreds of functional stove pipes. When the smoke comes out of the top and mixes, this is currently the opportunity for ecosystem management (integration). Yet, a large number of functional managers keep moving the pipes further away in order to maintain functional integrity. Most people who are actively involved in implementing ecosystem management see how such intense functionalism is counter productive. An integrated program will require incredibly strong leadership but it can be achieved by perforating our system to allow integration throughout the process.

PROCESS

There are plenty of ecosystem management processes to implement. Again, for the limited resources that we have it is important for us not to reinvent the wheel. A benefit to us is our close coordination with our Forest's plan revision process. It's amazing the resources that can be gathered if a landscape analysis and revision process combine.

There is a lot of emphasis at the Regional level on subregional assessment. It's important to try to keep in tune with that process so we can aggregate information up. Of equal importance is to have the ability to detail down to project level work. The tightrope one walks is getting specific enough so information can be used for landscape analysis but not so detailed that it answers all the project questions.

One of the toughest things we have worked on is how to bound the analysis. Some people want to collect information for the next ten years before they proceed while others are focused at too broad of an analysis. The best help we have received in bounding the analysis is to talk to people on other forests who have already been through the process.

SUMMARY

Ecosystem management is first and foremost a social question of how to maintain biodiversity while providing a myriad of goods and services. Ecosystem management will probably usher in the most complex way that humans have ever managed natural resources. As issues are presented in the context of the landscape, some will fade away, although as we learn more about social values and ecological processes numerous new issues will emerge. The Madison Range project will implement an ecosystem management process that emphasizes effective leadership, public involvement, collaboration, information management, and knowledge of ecological processes.

Notes

ECOSYSTEM MONITORING AND SAMPLING IN WHITEBARK PINE ECOSYSTEMS

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ABSTRACT

A summary of current and historic sampling in whitebark pine communities was compiled to provide managers and researchers with a reference list of sampling efforts. The reference list was developed to; 1) assist in coordinating sampling efforts; 2) provide sources and contacts for other sampling projects; and 3) assist individuals in sharing data. While compiling the reference list it became clear that considerable variation exists in sampling methodologies employed by the individual projects. To promote interchange of information, the Northern Region Ecological Data Methodology (ECODATA) (Keane et al. 1990) could be used to provide sampling consistency and compatibility between different resource and agencies across the region.

The reference list was stratified into two major groups, inventory and monitoring. Inventory (Table 1) includes both assessing whitebark pine communities to determine population dynamics, stand structure, tree vigor, health, and status, and assessing mapping efforts (ground-truthing) of different whitebark pine community types. Monitoring (Table 2) was defined as permanent plots or repeated measurements, and was divided into research and management applications. The reference list is not comprehensive, but we hope to revise and expand it as our interest and cooperation grows.

To facilitate consistent and compatible research and management sampling methodology for inventorying, monitoring and investigating whitebark pine communities across agencies, the Northern Region Ecological Data Methodology (ECODATA) is recommended. ECODATA is a valuable tool for ecosystem descriptions and evaluations (Jensen et al. 1994), and provides information in formats needed for developing adaptive management strategies. At a minimum the following ecological attributes are suggested to be measured using ECODATA methods:

1) Site conditions (e.g., slope, aspect, elevation),
2) Spatial location,
3) Detailed site description,
4) Disturbance history,
5) Vascular plant composition, height, and cover,
6) Tree diameter, height, age, and condition,
7) Forest floor organic matter, downed woody fuels, duff, litter, dead shrub and herbaceous, and
8) soil type and depth.

ECODATA methods that correspond to these measurement needs are General (GF), Location/Linkage (LL), Comments (CD), Disturbance History (DH), Plant Composition (PC), Measured Fuels (DW), and Tree Data (TD). This ecological sampling should be done on a fixed-area plot about 0.1 to 0.5 acres in size. It is also highly recommended that the plot be accurately located using a Global Positioning System, so it can be used in ground-truthing projects.

LITERATURE CITED

Keane, R. E., M. E. Jensen, and W.J. Hann. 1990. ECODATA and ECOPAC: analytical tool for integrated resource management. Compiler 8(3):24-37.

Jensen, M. E., W.J. Hann, R.E. Keane, J. Caratti, and P. S. Bourgeron. 1994. ECODATA -- A multiresource database and analysis system for ecosystem description and evaluation. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-318, Pacific Northwest Res. Stn., Portland, OR.

Table 1: INVENTORY

Category	Project/Description	Date	Contact
ASSESSMENT			
Insect & Disease	Mountain pine beetle survey on the Gallatin National Forest.	1980	Mark McGregor R1 Forest Pest Management
	Blister rust survey on the Stevensville and Darby RD, Bitterroot NF, to evaluate pruning potential.	1992-1993	Cathy Stewart Bitterroot NF Stevensville RD
	Identifying insects affecting whitebark pine cones and seeds, which will lead to a guide for monitoring cone and seed insect populations and management strategies.	1994	Nancy Campbell R1 Forest and Pest Management
	Monitoring flight of Mountain Pine Beetle using pheromone baited traps on Togwotee Pass in the Bridger-Teton and Shoshone NF.	?	Lynn Rasmussen Forest Science Lab Logan, Utah
	Evaluating blister rust severity on the Colville NF.	1993	Ryland Hardman Region 6, Colville NF.
	Northern Rocky Mountain blister rust inventory.	?	Ray Hoff, Forestry Sc. Lab, Moscow ID.
Fire History	Fire history sampling along the Continental Divide on the Wisdom RD (Beaverhead NF) and North Fork and Leadore RD (Salmon NF).	1994	Michael Murray U of Idaho, Forest, Wildlife, and Range Sciences
	Reproduction and stand structure of WBP in relation to fire and succession in Yellowstone National Park.	1990	Penny Morgan, College of Forestry, Wildlife & Range Sc., U of Idaho, Moscow
Cones & Seeds	Cone collection on the Red River RD, Nez Perce NF.	1994	Kurt Kluegel Red River RD Nez Perce NF
	Cone collection and developed methodology for collection on Green Mountain, in Fremont NF.	1992	Frederick VonBonin R6: Bly RD Fremont NF
	Methodology for estimating past cone crops of WBP from cone scars in Yellowstone NP.	1990	Penny Morgan, (see above in Fire History)
Ecology	Whitebark Pine Study - including image classification and mortality survey of the Bob Marshall Wilderness Complex.	1990-1992	Bob Keane, INT Intermountain Fire Science Lab, Missoula MT

INVENTORY, Continued

Category	Project/Description	Date	Contact
ASSESSMENT, Continued:			
Ecology (Cont.)	Whitebark pine community classification of Yellowstone National Park.	?	Don Despain Yellowstone NP
	Ecology of subalpine larch in the Pacific Northwest.	1970	Steve Arno, INT. Intermountain Fire Sc. Lab, Missoula MT
	Ecosystem process sampling for Region 1.	1992 +	Ceci McNicoll, RAWE R1, Missoula, MT
Wildlife	Grizzly bear habitat inventory on the South Fork of the Flathead river, by Dave Haddon, for Flathead NF.	1985	?, Region 1, ECODATA Database, Missoula MT
	Analysis of grizzly bear habitat and other wilderness resources in the Scapegoat Wilderness.	1982	John Craighead, U of M Foundation, U of M, Missoula, MT.
Modelling	FIRSUM validation plots collected in the Lower Bitterroot Mountains, including tree population and site information.	1987-1989	Bob Keane, INT. Intermountain Fire Science Lab, Missoula MT
GROUND TRUTHING			
Imagery	Ecodata plots collected in the Selway-Bitteroot Wilderness, on the Moose Creek RD, Nez Perce NF.	1992 & 1993	Mary Ann High Moose Creek RD Nez Perce NF
	Ground truth plots connected to grizzly bear habitat mapping, on the Rocky Mountain RD, Lewis and Clark NF.	?	Seth Diamond Rocky Mountain RD Lewis & Clark NF
	Flathead National Forest MSS Classification	1986-1990	Don Krogstad SO, Flathead NF
Mapping	Stand exams data on non-wilderness compartments south of Birch Creek on the Rocky Mountain RD, Lewis and Clark NF.	?	Seth Diamond Rocky Mountain RD Lewis & Clark NF
	Informal survey of locations of WBP stands, on the Cabinet RD, Kootenai NF.	?	Bob Lambrecht Cabinet RD Kootenai NF
	Stand exams, ECODATA plots, and aerial surveys of WBP stands were used in a landscape analysis of the entire North Fork of the Flathead NF.	1993	Beth Koss Glacier View RD Flathead NF
	Ecology plot data from Area 2 (eastern Washington) including Colville, Okanogan, and Wenatchee National Forests.	?	Brad Smith Okanogan NF Region 6

Table 2: MONITORING

Category	Project/Description	Date	Contact
MANAGEMENT			
Cones & Seeds	Cone Survey on the Bridger-Teton NF.	1990	Carol Eckert R4: Greys River RD Bridger-Teton NF
	Northern region (one) genetic resource program includes assessing genetic variation and establish natural seed orchards resistant to blister rust and involves several National Forests.	1991	Lars Halstrom Bozeman RD Gallatin NF
Regen-eration	Tree and vegetation recovery after stand replacement fire in Wheeler Creek (1993) and Charlotte Peak (1985) on the Flathead NF.	See Proj.	Maria Mantas SO Flathead NF
	Beartree Challenge - Three plantations of WBP were planted within stands burned by the Canyon Creek Fire on the Lewis & Clark NF.	1989	Seth Diamond Rocky Mountain RD Lewis & Clark NF
	Hornet-Wedge timber sale will use a combination of dozer piling and broadcast burning to create areas of bare mineral soil on the Flathead NF.	1993	Bryan Donner Glacier View RD Flathead NF
Silvi-culture	Foggy Dew Project - Precommerical thinning to favor WBP on the east side of the North Cascades Mountain Range.	1994	Pete Soderquist R6: Twisp RD Okanogan NF
RESEARCH			
Regen-eration	PHD on PIAL Regeneration on Beartooth Plateau, by Sabine Mellmann, PO Box 1044, Cooke City, MT. 59020.	Cur-rent	Kent Houston Region 2 Shoshone NF
	Three studies in conjunction with the INT Fire Science Lab, Missoula. MT. on applying silvicultural treatments and fire to subalpine fir stands to encourage regeneration and test rust resistant planting stock:		Steve Arno & Bob Keane INT Fire Science Lab Missoula MT
	1 - Coyote Meadow Study in the Sapphire Mountain on the Bitterroot NF,	1993	Cathy Stewart Stevensville RD
	2 - Smith Creek Study in the Bitterroot Mountains on the Bitterroot NF, and	1994	Bitterroot NF
	3 - Snow Bowl Ski area on the Lolo NF.	1993	Vic Dupuis Missoula RD, Lolo NF
	Plantation study of WBP regeneration on the Gallatin NF.	?	Ward McCaughey INT, Forest Science Lab, Bozeman

MONITORING, Continued

Category	Project/Description	Date	Contact
RESEARCH, Continued			
Regen-eration	Natural regeneration study in stand replacement and mixed-mortality fires in Yellowstone National Park.	1990	Diana Tomback (see below: Insect & Disease)
	Monitoring regeneration after stand replacement fires created from the Canyon Creek Fire (1988), around Bighorn Lake in the Scapegoat Wilderness.	1989	Wendel Hann, R1, RAWE, Missoula MT
Insect & Disease	The effects of blister rust on post-fire regeneration of WBP on the Sundance Burn (1967) located in the Selkirk Range on the Kaniksu NF, Idaho.	1992	Diana Tomback, Dept Biology & Center for Environ Sc., U of Colorado, Denver.
	Artificially inoculated natural WBP regeneration susceptible to white pine blister rust to evaluate rust resistance.	1992	Ray Hoff Forestry Science Lab Moscow ID.
	Monitoring blister rust movement and mortality in Western Montana, by remeasurement of Montana habitat type plots.	1971	Bob Keane INT Fire Science Lab Missoula MT

Notes

WHITEBARK PINE RESTORATION IN WILDERNESS

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INTRODUCTION

Maintaining naturalness is fundamental to our Wilderness preservation mission. Fire suppression and the white-pine blister rust disease have affected the naturalness of many Wildernesses. Should we be entertaining aggressive proposals to offset past management actions and the effects of exotic diseases? In the following "extended abstract," I will present an overview of Wilderness principles and how they may apply to restoration efforts and will also address planning considerations in whitebark pine restoration programs.

WILDERNESS PRINCIPLES AND RESTORATION

The Wilderness Preservation System is established "to assure that an increasing population...does not occupy and modify all areas..., leaving no lands designated for preservation and protection in their natural condition...[and] to secure for...present and future generations the benefits of an enduring resource of wilderness" (The Wilderness Act, Section 2(a)). Wilderness is defined as being "in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man.... An area of undeveloped Federal land retaining its primeval character and influence,...which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature..., (2) has outstanding opportunities for solitude [and] a primitive and unconfined type of recreation,... and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value" (Wilderness Act Section 2(c)).

The general theme of requirements to be found in Wilderness is naturalness and a setting that allows for solitude. Restoration efforts have generally focused on site problems resulting from over-use or inappropriate visitor use. Traditional and very successful efforts of restoration have been targeted at restoring campsites thus creating settings more conducive to providing for a sense of solitude for recreationists. These restored sites often contribute to maintaining natural systems when native plant species are used in restoration efforts. An example of a larger scale restoration project is the ongoing program to control noxious weeds in the Bob Marshall, Scapegoat, and Great Bear Wildernesses. Restoring plants and animals over a very broad landscape has generally not been attempted. You may ask, "why haven't broad efforts occurred? Are there or are there not broader restoration needs in Wilderness?" I will address these questions as they relate to three of the principles of Wilderness management as discussed in Wilderness Management by Hendee, Stankey, and Lucas.

Manage Wilderness as one extreme on the environmental modification spectrum

Wilderness is presumed to be in a relatively undisturbed condition. Intuitively, intensive management in Wilderness is not needed, nor appropriate. We should promote natural events to control environmental conditions. We should also not promote any one ecological condition or species. Intensive modification efforts in themselves could be perceived as creating other unnatural conditions and could also diminish the ability of visitors to find solitude. To partially compensate for the effects of fire suppression and blister-rust, some are advocating planting blister rust resistant whitebark pine in Wilderness. Many have used exotic grass species to rehabilitate trails and campsites. It is possible that these management approaches may have unforeseen long-term ecological consequences as genotypes are diluted or native species are out competed. We should use natural processes and local native plants wherever practicable to restore Wilderness conditions.

Manage Wilderness as a composite resource, not as separate parts

Wilderness is a composite resource with interrelated parts, and its management must be focused on the whole, not on those component parts. Ideally, we would have integrated plans that addressed most of the elements of a Wilderness. Restoration efforts focused on only one element may benefit a part, but could degrade the whole. An example of this would be to allow fire to play a more natural role where this would indirectly allow for the spread of exotic vegetation such as noxious weeds. There may be higher needs then focusing on restoring only whitebark pine; needs that may be identified in integrated resource analyses.

Manage human influences, a key to Wilderness protection

To maintain natural ecological systems in Wilderness, we must be concerned with the management of human use and influences. Human influence has created unnatural vegetation patterns resulting from fire prevention and suppression. The altering of vegetation has indirectly altered wildlife populations. Expanding human use have affected wildlife population structure and function. We must involve the public to help managers identify approaches for maintaining or restoring natural conditions while preserving an acceptable level of solitude and primitive recreation experiences. The reintroduction of natural fire regimes in Wilderness is desirable and will allow for visitors to experience a Wilderness environment. However, many current recreationists and off site publics may resent seasons of smoke and assorted other inconveniences.

The definition of "natural" is key in helping us understand our Wilderness stewardship mission. What is the role of "humans" in Wilderness? Are humans an integral natural part of the Wilderness? American Indians did influence ecosystems with their use of fire, hunting and gathering activities, and with settlements. However, American Indians before obtaining European technology did not have a dominant effect on natural systems. The Wilderness Act clearly equates naturalness to an era when humans did not permanently alter ecological processes.

Multi-decade fire suppression and the introduction of exotics, including white-pine blister rust, are clearly trammeling effects of modern human on natural processes.

PLANNING CONSIDERATIONS IN RESTORATION PROGRAMS

What does success look like for the restoration of whitebark pine in Wilderness? What conditions are acceptable and what actions are needed to protect or achieve those conditions? Would those actions affect other elements of the Wilderness resource or create other problems? Will the action have net benefits for the Wilderness resource? These are some of the basic questions that need to be answered when we propose restoration projects. Following is an example of how these questions may be approached using the Bob Marshall Wilderness Complex (BMWC) area as an example.

The Forest Plan Limits of Acceptable Change (LAC) direction for the BMWC provides recreation management direction, area-wide goals and guidelines, identification of wilderness recreation opportunity classes, and standards for resource and social indicators. The heart of the LAC process is to manage the BMWC in a way that will "perpetuate the opportunity for each visitor to enrich their experience to the fullest without unduly limiting the freedom to interact alone with nature." The central management thrust in the BMWC is "to permit natural processes to operate uninhibited by human influence..."

The Spotted Bear Ranger District, Flathead National Forest, has initiated a Landscape Analysis project for the South Fork of Flathead River Geographic Area within the BMWC. Stepping down from the Forest Plan direction, and using field monitoring information, this analysis will identify resource conditions and restoration needs in the area. Issues being addressed will include in part restoration of whitebark pine, control of exotic vegetation, recovering the grizzly bear, and improving recreation conditions. I believe that expanded efforts to restore whitebark pine will be identified as a need when the analysis is completed. The South Fork analysis approach will be expanded throughout the BMWC when feasible.

David Cole, Aldo Leopold Wilderness Research Institute, summarized some considerations for a comprehensive restoration plan. The plan should contain at least the five following elements: (1) Specific statements of goals and objectives; (2) a careful analysis of the situation within which the problem occurs, (3) an explicit program of restoration and maintenance; (4) an explicit monitoring program; and (5) an action plan that outlines budgets, responsibilities, and timelines. Any site specific Wilderness restoration plan should include these considerations, must promote the Wilderness resource, and follow National Environmental Policy Act planning process steps.

CONCLUSION

Ecosystem management, Wilderness stewardship, and whitebark pine restoration are all related to understanding natural ecological systems. In Wilderness, maintaining natural ecological systems should be the focus of our stewardship mission. As we identify serious problems that must be addressed to preserve the natural integrity of Wilderness, we must correct the situation. In some cases this will be difficult due to costs, negative effects on other resources, and hardships that the actions may cause some people. However, if we do not act we will be impairing these areas for future use as Wilderness. Lack of actions may also prevent us from achieving our regional ecosystem management needs.

Notes

WHITEBARK PINE CONE DEVELOPMENT AND COLLECTIONS IN 1993

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ABSTRACT

Most of the residents in Montana were wondering if summer was left off the calendar for 1993. Cities across the state were reporting record low temperatures and record high precipitation throughout the summer. Phenology of whitebark pine reproductive and vegetative buds, seed ripening and seed harvesting by the Clark's nutcracker were affected.

Mike Johnson, Missoula Fire Weather Office, has summarized in table 1., the average monthly temperatures (max. + min./2) and precipitation for several National Weather Service and Federal Aviation Administration offices. Significant extreme changes in this table are a departure of -10.2 degrees Fahrenheit for July from normal for the Great Falls office and 4.9 inches or 537.5% of normal for July precipitation at the Kalispell office. Other weather data also can be obtained from the Soil Conservation Service Snotel stations that are located in the field at a variety of elevations. They were unable to supply this data in time for this writing. These remote weather stations should provide more accurate data for the specific area cones are being collected in.

In a normal season, whitebark pine cones can become ripe for harvest starting in the middle of August, for areas in the rocky mountains of Montana. Collections are started when embryo length is more than 75% of the embryo cavity. The 1993 collections were made 2-3 weeks later this year. Temperatures in the Copper Creek drainage northeast of Lincoln were abnormally cool. Some collections were made in three inches of snow on the ground. Temperature data for this specific site was not taken. However, if we use the average monthly temperatures from the closest office in Great Falls and use the adiabatic lapse rate of lowering the temperature 3.5 degrees Fahrenheit for every 1,000 feet of elevational rise from 3,674 feet to the average elevation of 7,600 feet at the collection area, or approximately 4,000 feet and a decrease of 14 degrees. The highest monthly temperature average at the Great Falls office occurred in August at 60.5 degrees Fahrenheit. After correcting for elevation at the Copper Creek area, the temperature would be 46.5 degrees Fahrenheit. At this temperature, seed ripening and bud development slows down significantly.

Ward McCaughey, scientist at the Intermountain Lab in Bozeman, was planning to do some controlled crosses on whitebark pine in the Palmer mountain area near Gardiner. He observed cone flower receptivity about a month behind normal. In the Copper Creek area and at the Alder Creek lodgepole pine test plantation southwest of Wiseriver, we observed lodgepole pine shoot phenology stopping at

the pin feather stage of development. We also observed that needle lengths were half the length of the previous years on trees that completed their developmental cycle.

Clark's nutcracker harvesting significantly affected our collection efforts. In a normal year, the Clark's nutcracker will start harvesting the seed about a week after they have tested some cones for ripeness. When the whitebark pine seed is ripe, the Clark's nutcracker can extract the seed from the cone after breaking off the outer tips of the cone scales. Because of slow ripening from low temperatures, the Clark's nutcracker had ruined most of the seed before we could collect the cones. Since immature seed can't be extracted with the seed coat intact, most of the seed that the Clark's nutcracker harvested was from seeds that they broke open and extracted the contents. We were able to move to another ridge nearby where the Clark's nutcracker hadn't gone through as intensely and ruined the seed for our collection purposes.

Table 2. shows the whitebark pine collection data off of the Northern Region's National Forests to date. This seed will be used by scientists at the Intermountain Station lab in Moscow, Idaho, for several studies. Our collection goal is to get 1,000 seed from 10 trees, from 4-5 collection areas on each National Forest in the Northern Region. Because of the low temperatures in the summer of 1993 we may not have any cones in some whitebark pine areas for the 1994 season. The whitebark pine collections may not get completed until the 1995 season.

Table 1- A SUMMARY OF TEMPS/PRECIP FOR THE PERIOD MAR 1993 THROUGH FEB 1994 QTR = DEC-FEB

		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	ANN	OCT-FEB	QTR
GEG	TEMP	37.8	45.5	59.8	60.2	60.2	64.2	58.7	50	29.4	30.9	35.6	29.1			
	DEP	-0.9	-0.4	5.9	-1.8	-8.6	-4.2	-0.2	2.7	-5.7	3.1	8.5	-4.2	-0.48	0.88	2.47
	PCPN	1.13	1.9	1.36	0.48	2.08	1.24	0.28	0.42	0.68	1.8	1.43	0.83	13.63	5.16	4.06
	DEP	-0.36	0.72	-0.05	-0.78	1.41	0.52	-0.45	-0.57	-1.47	-0.62	-0.55	-0.66	-2.86	-3.87	-1.83
		75.8%	161.0%	96.5%	38.1%	310.4%	172.2%	38.4%	42.4%	31.6%	74.4%	72.2%	55.7%	82.7%	57.1%	68.9%
LWS	TEMP	46.4	50.1	62.9	63.9	65.4	70.2	64.7	54.4	35.2	36	40.4	35.6			
	DEP	2.3	-0.5	4.5	-3	-8.7	-3.5	0.6	2.1	-4.9	1.5	6.8	-3.5	-0.53	0.40	1.60
	PCPN	1.17	2.78	1.97	1.63	1.19	0.62	0.07	0.67	0.64	0.8	0.89	0.74	13.17	3.74	2.43
	DEP	0.08	1.65	0.66	0.38	0.52	-0.16	-0.71	-0.23	-0.51	-0.4	-0.39	-0.15	0.74	-1.68	-0.94
		107.3%	246.0%	150.4%	130.4%	177.6%	79.5%	9.0%	74.4%	55.7%	66.7%	69.5%	83.1%	106.0%	69.0%	72.1%
FCA	TEMP	35.4	44.2	57.9	57.9	57.4	60.4	52.4	44.2	25.9	27.6	32	20.9			
	DEP	1.7	1	6.6	-0.9	-6.2	-2.5	-0.8	2.3	-5.1	4.9	11.5	-5.7	0.57	1.58	3.57
	PCPN	0.62	2.2	1.93	3.46	6.02	1.49	1.61	1.01	1.2	1.58	1.09	1.41	23.62	6.29	4.08
	DEP	-0.4	1.1	0.06	1.25	4.9	0.09	0.35	0.14	-0.1	-0.15	-0.44	0.31	7.11	-0.24	-0.28
		60.8%	200.0%	103.2%	156.6%	537.5%	106.4%	127.8%	116.1%	92.3%	91.3%	71.2%	128.2%	143.1%	96.3%	93.6%
MSO	TEMP	38.5	44.7	58.8	58.3	59.4	63.2	55.5	46.1	27	27.6	33.8	26.3			
	DEP	2.7	0.5	7	-1.7	-7.4	-2.6	-0.2	1.9	-5.4	4.2	11.1	-2.9	0.60	1.78	4.13
	PCPN	0.66	1.83	1.99	1.45	2.02	1.32	0.35	2	0.46	0.4	0.35	0.49	13.32	3.70	1.24
	DEP	-0.31	0.87	0.21	-0.33	1.11	0.12	-0.77	1.26	-0.35	-0.76	-0.89	-0.3	-0.14	-1.04	-1.95
		68.0%	190.6%	111.8%	81.5%	222.0%	110.0%	31.3%	270.3%	56.8%	34.5%	28.2%	62.0%	99.0%	78.1%	38.9%
HLN	TEMP	36.4	44.3	57.3	58.5	59.5	61.5	54	43.8	26.2	30	29.8	20.7			
	DEP	2.8	0.9	4.8	-3.6	-9.7	-5.9	-1.4	-1.3	-5.4	6.5	10.2	-5.7	-0.65	0.86	3.67
	PCPN	0.56	1.63	1.71	3.14	4.7	2.79	1.25	0.71	0.36	0.13	0.2	0.4	17.58	1.80	0.73
	DEP	-0.17	0.66	-0.07	1.27	3.6	1.5	0.1	0.11	-0.12	-0.46	-0.43	-0.01	5.98	-0.91	-0.90
		76.7%	168.0%	96.1%	167.9%	427.3%	216.3%	108.7%	118.3%	75.0%	22.0%	31.7%	97.6%	151.6%	66.4%	44.8%
GTF	TEMP	37.6	43.7	55.4	56.5	58	60.5	52.5	46.2	28.1	33.5	27.3	17.2			
	DEP	4.3	0.1	2.3	-5.1	-10.2	-6.4	-4.1	-1.3	-5.8	9.6	6.1	-10.2	-1.73	-0.32	1.83
	PCPN	0.86	3.16	2.74	2.58	4.68	3.04	1.71	1.1	0.97	0.3	0.44	0.53	22.11	3.34	1.27
	DEP	-0.24	1.75	0.22	0.19	3.44	1.5	0.47	0.32	0.31	-0.55	-0.47	-0.04	6.90	-0.43	-1.06
		78.2%	224.1%	108.7%	107.9%	377.4%	197.4%	137.9%	141.0%	147.0%	35.3%	48.4%	93.0%	145.4%	88.6%	54.5%
BIL	TEMP	40.6	47	59.8	62.2	62.7	65.6	57	47.5	31.4	33.7	28.2	22.5			
	DEP	5.1	1.4	4.8	-2.6	-9.8	-5.1	-2.1	-1.6	-3.7	8.2	5.4	-6.5	-0.54	0.36	2.37
	PCPN	0.5	1.86	0.4	2.05	5.08	0.69	1.76	2.11	0.26	0.2	0.34	0.36	15.61	3.27	0.90
	DEP	-0.66	0.12	-2.17	0.06	4.14	-0.32	0.4	0.97	-0.58	-0.59	-0.56	-0.28	0.53	-1.04	-1.43
		43.1%	106.9%	15.6%	103.0%	540.4%	68.3%	129.4%	185.1%	31.0%	25.3%	37.8%	56.3%	103.5%	75.9%	38.6%
GGW	TEMP	34.4	45.8	57.8	61.2	62.7	64.5	54.4	44.8	25.1	23.3	7.6	5.1			
	DEP	5	1.5	2.8	-3.2	-8.1	-4.9	-2.9	-1.3	-4.1	8.1	-3	-12.4	-1.88	-2.54	-2.43
	PCPN	0.82	0.43	0.5	1.96	5.93	4.31	0.6	0.47	0.58	0.13	0.72	0.33	16.78	2.23	1.18
	DEP	0.41	-0.26	-1.27	-0.15	4.21	2.96	-0.4	-0.14	0.3	-0.25	0.35	0.06	5.82	0.32	0.16
		200.0%	62.3%	28.2%	92.9%	344.8%	319.3%	60.0%	77.0%	207.1%	34.2%	194.6%	122.2%	153.1%	116.8%	115.7%
MLS	TEMP	36.8	46.7	58.9	62.4	64.2	67.7	56.9	46.8	29	30.1	17.3	13.8			
	DEP	3.5	0.7	2	-4.6	-8.3	-4.8	-1.8	-1.2	-3.1	10.9	1.3	-9.5	-1.24	-0.32	0.90
	PCPN	0.77	2.22	1.04	4.71	6.34	1.04	0.13	1.13	0.34	0.09	0.93	0.31	19.05	2.80	1.33
	DEP	0.15	0.86	-1.23	1.94	4.79	-0.11	-1.14	0.23	-0.2	-0.55	0.38	-0.14	4.98	-0.28	-0.31
		124.2%	163.2%	45.8%	170.0%	409.0%	90.4%	10.2%	125.6%	63.0%	14.1%	169.1%	68.9%	135.4%	90.9%	81.1%
HVR	TEMP	35.8	45.3	56.9	59.7	61	62.9	53.3	45.4	26.6	28.9	13.8	5.7			
	DEP	4.7	1.5	2.2	-4	-8.7	-5.4	-3.2	-0.4	-3	11.5	-0.8	-15.4	-1.75	-1.62	-1.57
	PCPN	0.85	1.16	1.24	2.2	5.38	2.02	0.75	0.06	0.54	0.27	1.01	0.67	16.15	2.55	1.95
	DEP	0.19	0.22	-0.42	0.44	3.98	0.79	-0.43	-0.47	0.16	-0.26	0.48	0.31	4.99	0.22	0.53
		128.8%	123.4%	74.7%	125.0%	384.3%	164.2%	63.6%	11.3%	142.1%	50.9%	190.6%	186.1%	144.7%	109.4%	137.3%
BTM	TEMP	33.6	38.9	52.3	52.9	54.7	56.4	50.8	41.5	23.5	19.5	28.1	18.8			
	DEP	5.3	1.5	5	-2.4	-8.3	-4.4	-0.3	0.5	-4	-0.1	12.6	-3.2	0.18	1.16	3.10
	PCPN	0.43	1.45	1.82	4.3	3.05	3.21	0.14	1.26	0.31	0.57	0.19	0.41	17.14	2.74	1.17
	DEP	-0.33	0.53	-0.04	2.15	1.79	1.9	-1.12	0.57	-0.22	0.13	-0.36	0.04	5.04	0.16	-0.19
		56.6%	157.6%	97.8%	200.0%	242.1%	245.0%	11.1%	182.6%	58.5%	129.5%	34.5%	110.8%	141.7%	106.2%	86.0%

GEG = SPOKANE, WA
LWS = LEWISTON, ID
FCA = KALISPELL
MSO = MISSOULA
HLN = HELENA
GTF = GREAT FALLS
BIL = BILLINGS
GGW = GLASGOW
MLS = MILES CITY
HVR = HAVRE
BTM = BUTTE

QTR = DEC THRU FEB DEP = DEPARTURE FROM NORMAL % = PERCENT OF NORMAL

Table 2-WBP Seed Bank

FOR/DIST	ELEV.	STAND	COLLECTION AREA	TREE ID	T-R-S	NO.SEED	NO.CONES	SEED/CONE	G/100	TOTAL GRAMS	LOT	COLL. DATE
010201	8400	119-03-023	Goldstone Pass	01	08S-16W-10	619	13	48	12.06	74.67	93	8-28-92
010201	8400	119-03-024	Goldstone Pass	02	08S-16W-10	563	13	43	13.44	75.63	81	8-28-92
010201	8400	119-03-024	Goldstone Pass	03	08S-16W-10	859	12	72	14.17	121.69	72	8-28-92
010201	8400	119-03-024	Goldstone Pass	04	08S-16W-10	1416	18	79	15.05	213.19	52	8-28-92
010201	8400	119-03-024	Goldstone Pass	05	08S-16W-10	1100	16	69	16.75	184.35	48	8-28-92
010201	8400	119-03-024	Goldstone Pass	06	08S-16W-10	1332	12	111	11.90	158.47	69	8-28-92
010201	8400	119-03-024	Goldstone Pass	07	08S-16W-10	1060	~	~	11.29	119.70	44	8-28-92
010201	8400	119-03-024	Goldstone Pass	08	08S-16W-10	331	11	30	17.75	58.73	84	8-28-92
010201	8400	119-03-024	Goldstone Pass	09	08S-16W-10	1774	17	104	8.61	152.75	56	8-28-92
010201	8400	119-03-024	Goldstone Pass	10	08S-16W-10	1244	15	83	9.60	119.44	34	8-28-92
010202	7900	244-08-072	Mudd Ridge	A	02N-15W-27	85	10	9	~	12.75	25	8-18-92
010202	7900	244-08-072	Mudd Ridge	B	02N-15W-27	558	18	32	16.13	90.00	125	8-18-92
010202	7900	244-08-072	Mudd Ridge	C	02N-15W-27	428	14	31	18.58	79.47	91	8-18-92
010202	7900	244-08-072	Mudd Ridge	D	02N-15W-27	216	18	12	16.37	35.34	87	8-18-92
010202	7900	244-08-072	Mudd Ridge	E	02N-15W-27	561	12	47	18.44	103.48	26	8-18-92
010202	7900	244-08-072	Mudd Ridge	F	02N-15W-27	301	15	20	15.53	46.75	99	8-18-92
010202	7900	244-08-072	Mudd Ridge	G	02N-15W-27	332	14	24	23.18	76.97	98	8-18-92
010202	7900	244-08-072	Mudd Ridge	H	02N-15W-27	285	14	20	15.04	42.93	88	8-18-92
010202	7900	244-08-072	Mudd Ridge	I	02N-15W-27	394	12	33	16.94	66.67	92	8-18-92
010202	7900	244-08-072	Mudd Ridge	J	02N-15W-27	354	16	22	18.32	64.81	124	8-18-92
010203	8550	335-09-038	Ajax Lake	01	06S-17W-07	803	14	57	9.23	74.13	70	8-27-92
010203	8550	335-09-038	Ajax Lake	02	06S-17W-07	1174	15	78	10.91	128.08	51	8-27-92
010203	8550	335-09-038	Ajax Lake	03	06S-17W-07	741	17	44	10.11	74.92	36	8-27-92
010203	8550	335-09-038	Ajax Lake	04	06S-17W-07	806	13	62	10.33	83.23	29	8-27-92
010203	8550	335-09-038	Ajax Lake	05	06S-17W-07	479	12	40	10.76	51.50	33	8-27-92
010203	8550	335-09-038	Ajax Lake	06	06S-17W-07	544	7	78	11.82	64.35	24	8-27-92
010203	8550	335-09-038	Ajax Lake	07	06S-17W-07	927	12	77	9.77	90.53	123	8-27-92
010203	8550	335-09-038	Ajax Lake	08	06S-17W-07	404	8	50	11.79	47.61	37	8-27-92
010203	8550	335-09-038	Ajax Lake	09	06S-17W-07	601	12	50	8.32	49.98	82	8-27-92
010203	8550	335-09-038	Ajax Lake	10	06S-17W-07	1049	11	95	9.84	103.26	75	8-27-92
010207	8800	713-02-038	W.F.Cabin	01	12S-02W-05	2509	48	52	13.12	329.23	114	9-02-92
010207	8800	713-02-038	W.F.Cabin	02	12S-02W-05	1101	25	44	13.55	149.25	122	9-02-92
010207	8800	713-02-038	W.F.Cabin	03	12S-02W-05	622	11	57	15.99	99.47	109	9-02-92
010207	8800	713-02-038	W.F.Cabin	04	12S-02W-05	4204	75	56	17.86	750.83	78	9-02-92
010207	8800	713-02-038	W.F.Cabin	05	12S-02W-05	1275	28	46	10.75	137.12	115	9-02-92
010207	8800	713-02-038	W.F.Cabin	06	12S-02W-05	1529	56	27	14.25	217.88	100	9-02-92
010207	8800	713-02-038	W.F.Cabin	07	12S-02W-05	4128	73	57	12.01	495.76	97	9-02-92
010207	8800	713-02-038	W.F.Cabin	08	12S-02W-05	1056	21	50	13.31	140.53	32	9-02-92
010207	8800	713-02-038	W.F.Cabin	09	12S-02W-05	1071	16	67	17.83	190.95	108	9-02-92
010207	8800	713-02-038	W.F.Cabin	10	12S-02W-05	856	19	45	12.78	109.41	107	9-02-92
010207	9000	708-02-013	BLack Butte	01	10S-02W-35	960	15	64	10.90	104.63	105	9-02-92
010207	9000	708-02-013	Black Butte	02	10S-02W-35	5843	64	91	11.33	661.96	73	9-02-92
010207	9000	708-02-013	Black Butte	03	10S-02W-35	1353	22	61	13.44	181.80	101	9-02-92
010207	9000	708-02-013	Black Butte	04	10S-02W-35	4428	66	67	12.01	531.80	110	9-02-92
010207	9000	708-02-013	Black Butte	05	10S-02W-35	2099	39	54	15.81	331.85	103	9-02-92
010207	9000	708-02-013	Black Butte	06	10S-02W-35	757	14	54	11.01	83.30	121	9-02-92
010207	9000	708-02-013	Black Butte	07	10S-02W-35	1417	41	35	15.87	224.87	106	9-02-92
010207	9000	708-02-013	Black Butte	08	10S-02W-35	1493	34	44	14.08	210.17	113	9-02-92
010207	9000	708-02-013	Black Butte	09	10S-02W-35	2160	50	43	14.72	317.94	102	9-02-92
010207	9000	708-02-013	Black Butte	10	10S-02W-35	1844	38	49	10.82	199.52	90	9-02-92
010207	9000	708-02-013	Black Butte	11	10S-02W-35	1618	29	56	13.79	223.10	112	9-02-92
010301	7640	112-02-201	Signal Crk.	07	07N-18W-32	1102	15	73	5.04	55.55	166	8-20-93
010301	7640	112-02-201	Signal Crk.	05	07N-18W-33	1872	36	52	9.31	174.28	155	8-20-93
010301	7660	112-02-201	Signal Crk.	06	07N-18W-33	1490	25	60	000	94.23	146	8-17-93
010301	7660	112-02-201	Signal Crk.	02	07N-18W-32	648	24	27	6.02	39.00	152	8-20-93
010301	7660	112-02-201	Signal Crk.	03	07N-18W-32	878	17	52	6.53	57.31	170	8-20-93
010301	7680	112-02-201	Signal Crk.	08	07N-18W-32	1264	20	63	9.05	114.37	160	8-20-93
010301	7690	112-02-201	Signal Crk.	04	07N-18W-32	1186	20	59	5.86	69.48	167	8-20-93
010301	7880	112-02-201	Signal Crk.	01	07N-18W-32	952	21	45	5.21	49.60	168	8-20-93
010301	7910	115-03-225	Signal Crk.	10	07N-18W-32	958	16	60	7.22	69.16	204	8-23-93
010301	7910	115-03-225	Signal Crk.	09	07N-18W-32	537	14	38	8.39	45.09	202	8-20-93
010302	7550	240-02-118	Dam Crk.	01	06N-18W-13	261	10	26	7.60	19.83	159	8-24-93
010302	7550	240-02-118	Dam Crk.	02	06N-18W-13	59	14	4	~	7.78	148	8-24-93
010302	7600	240-02-118	Dam Crk.	03	06N-18W-13	767	12	64	6.56	73.37	169	8-24-93
010302	7600	240-02-118	Dam Crk.	04	06N-18W-13	810	14	58	6.85	55.51	162	8-24-93
010302	7600	240-02-118	Dam Crk.	05	06N-18W-13	663	13	51	8.62	57.11	149	8-24-93
010302	7650	240-02-118	Dam Crk.	06	06N-18W-13	522	12	44	5.74	29.97	158	8-24-93
010302	7700	240-02-118	Dam Crk.	07	06N-18W-13	785	16	49	6.24	48.96	203	8-24-93
010302	7700	240-02-118	Dam Crk.	08	06N-18W-13	319	10	32	8.66	27.64	161	8-24-93
010302	7750	240-02-118	Dam Crk.	09	06N-18W-13	273	14	20	8.30	22.70	153	8-24-93
010302	7750	240-02-118	Dam Crk.	10	06N-18W-13	1037	15	69	6.54	67.81	163	8-24-93
010303	7950	314-07-033	Saddle Mtn.	02	01S-19W-32	431	20	22	6.28	27.07	147	8-25-93
010303	7950	314-07-033	Saddle Mtn.	03	01S-19W-32	318	14	23	9.64	30.67	165	8-25-93
010303	7950	314-07-033	Saddle Mtn.	04	01S-19W-32	517	11	47	6.73	34.78	150	8-25-93

Table 2-WBP Seed Bank

FOR/DIST	ELEV.	STAND	COLLECTION AREA	TREE ID	T-R-S	NO.SEED	NO.CONES	SEED/CONE	G/100	TOTAL GRAMS	LOT	COLL. DATE
010303	7950	314-07-033	Saddle Mtn.	01	01S-19W-32	294	11	27	10.74	31.54	164	8-25-93
010303	8010	314-07-033	Saddle Mtn.	05	01S-19W-32	326	15	22	8.72	28.39	205	8-25-93
010303	8025	314-07-039	Saddle Mtn.	07	01S-19W-32	923	24	38	6.96	64.23	156	8-30-93
010303	8025	314-07-039	Saddle Mtn.	08	01S-19W-32	823	25	33	5.92	48.74	154	8-30-93
010303	8160	314-07-042	Saddle Mtn.	06	01S-19W-32	486	19	26	6.30	30.59	207	8-25-93
010303	8160	314-07-042	Saddle Mtn.	09	01S-19W-32	539	16	34	6.13	33.05	208	8-30-93
010303	8190	314-07-042	Saddle Mtn.	10	01S-19W-32	509	14	36	6.25	31.79	157	8-31-93
010802	9300	202-01-057	Picket Pin	01	04S-14E-31	230	15	15	10.50	24.20	135	8-22-91
010802	9300	202-01-057	Picket Pin	02	04S-14E-31	760	27	28	13.49	102.49	128	8-22-91
010802	9300	202-01-057	Picket Pin	03	04S-14E-31	477	30	16	15.03	71.74	129	8-22-91
010802	9300	202-01-057	Picket Pin	04	04S-14E-31	311	27	12	11.48	35.66	130	8-22-91
010802	9300	202-01-057	Picket Pin	05	04S-14E-31	348	23	15	12.75	44.40	131	8-22-91
010802	9300	202-01-057	Picket Pin	06	04S-14E-31	712	28	26	11.65	82.91	132	8-22-91
010802	9300	202-01-057	Picket Pin	07	04S-14E-31	707	23	31	9.38	66.29	133	8-22-91
010802	9300	202-01-057	Picket Pin	08	04S-14E-31	540	15	36	11.24	60.74	134	8-22-91
010802	9300	202-01-057	Picket Pin	09	04S-14E-31	885	20	44	10.88	96.31	139	8-22-91
010802	9300	202-01-057	Picket Pin	10	04S-14E-31	785	22	36	8.59	67.43	144	8-22-91
010802	8900	209-04-033	Hellroaring I	A	09S-19E-18	542	14	39	13.46	72.94	76	9-05-92
010802	8900	209-04-033	Hellroaring I	B	09S-19E-18	268	16	17	12.03	32.29	117	9-05-92
010802	8900	209-04-033	Hellroaring I	C	09S-19E-18	539	13	41	14.76	79.57	77	9-05-92
010802	8900	209-04-033	Hellroaring I	D	09S-19E-18	285	11	26	14.28	40.72	30	9-05-92
010802	8900	209-04-033	Hellroaring I	E	09S-19E-18	377	15	25	13.04	49.11	95	9-05-92
010802	8900	209-04-033	Hellroaring I	F	09S-19E-18	259	10	26	14.06	36.37	104	9-05-92
010802	8900	209-04-033	Hellroaring I	G	09S-19E-18	500	14	36	14.39	72.00	111	9-05-92
010802	8900	209-04-033	Hellroaring I	H	09S-19E-18	450	13	35	11.85	53.29	54	9-05-92
010802	8900	209-04-033	Hellroaring I	I	09S-19E-18	654	13	50	13.37	87.44	59	9-05-92
010802	8900	209-04-033	Hellroaring I	J	09S-19E-18	284	11	26	13.43	38.12	116	9-05-92
010802	9200	209-04-036	Hellroaring II	A	09S-18E-13	561	14	40	11.71	65.66	60	9-05-92
010802	9200	209-04-036	Hellroaring II	B	09S-18E-13	730	14	52	10.78	78.70	96	9-05-92
010802	9200	209-04-036	Hellroaring II	C	09S-18E-13	883	15	59	14.92	131.68	64	9-05-92
010802	9200	209-04-036	Hellroaring II	D	09S-18E-13	1436	18	80	10.37	148.96	41	9-05-92
010802	9200	209-04-036	Hellroaring II	E	09S-18E-13	637	15	43	12.51	79.67	50	9-05-92
010802	9200	209-04-036	Hellroaring II	F	09S-18E-13	1134	18	63	11.88	134.76	74	9-05-92
010802	9200	209-04-036	Hellroaring II	G	09S-18E-13	671	15	45	13.07	87.71	67	9-05-92
010802	9200	209-04-036	Hellroaring II	H	09S-18E-13	1024	15	68	13.84	141.68	89	9-05-92
010802	9200	209-04-036	Hellroaring II	I	09S-18E-13	688	14	49	16.25	111.78	83	9-05-92
010802	9200	209-04-036	Hellroaring II	J	09S-18E-13	641	15	43	15.61	100.07	66	9-05-92
010802	9200	202-02-040	Lower Iron Mtn.	02	04S-14E-31	627	15	42	9.76	61.22	136	8-22-91
010802	9200	202-02-040	Lower Iron Mtn.	03	04S-14E-31	213	22	10	12.12	25.76	137	8-22-91
010802	9200	202-02-040	Lower Iron Mtn.	04	04S-14E-31	1662	45	37	12.05	200.24	138	8-22-91
010802	9200	202-02-040	Lower Iron Mtn.	06	04S-14E-31	810	25	32	12.02	97.41	140	8-22-91
010802	9200	202-02-040	Lower Iron Mtn.	07	04S-14E-31	1159	50	23	12.07	139.83	141	8-22-91
010802	9200	202-02-040	Lower Iron Mtn.	08	04S-14E-31	1340	23	58	10.71	143.54	142	8-22-91
010802	9200	202-02-040	Lower Iron Mtn.	09	04S-14E-31	1051	21	50	11.07	116.33	143	8-22-91
010802	9700	202-03-032	Upper Iron Mtn.	01	05S-13E-13	658	13	51	6.39	42.05	22	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	02	05S-13E-13	632	14	5	8.27	52.29	42	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	03	05S-13E-13	715	13	55	4.70	33.63	46	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	04	05S-13E-13	597	13	46	7.60	45.40	49	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	05	05S-13E-13	964	13	74	8.06	77.71	68	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	06	05S-13E-13	984	14	70	9.35	92.04	80	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	07	05S-13E-13	756	13	58	6.19	46.81	86	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	08	05S-13E-13	1093	14	78	6.19	67.63	120	9-09-92
010802	9700	202-03-032	Upper Iron Mtn.	09	05S-13E-13	838	14	60	5.72	47.96	126	9-09-92
010903	8000	319-02-001	Cable Mtn.	BULK	05N-13W-03	5921	126	47	13.30	787.53	23	8-19-92
010903	8400	339-02-018	Mt. Emerine	BULK	05N-16W-07	6818	118	56	11.44	779.95	39	8-20-92
010903	8000	315-05-041	Powell Mine	BULK	07N-12W-23	6919	136	51	14.87	1028.92	47	8-19-92
010904	8200	402-07-741	Fleecer	BULK	01N-10W-11	12147	365	33	14.00	1700.64	118	8-31-92
010904	7600	202-03-026	Occidental Plateau	01	07N-05W-02	114	10	11	12.65	14.40	201	8-25-93
010904	7600	202-03-026	Occidental Plateau	02	07N-05W-02	208	10	21	7.91	16.47	209	8-25-93
010904	7600	202-03-026	Occidental Plateau	03	07N-05W-02	162	10	12	9.16	14.80	210	8-25-93
010904	7600	202-03-026	Occidental Plateau	04	07N-05W-02	43	10	4	N/A	4.04	211	8-25-93
010904	7600	202-03-026	Occidental Plateau	05	07N-05W-02	59	10	5	N/A	5.59	212	8-25-93
010904	7600	202-03-026	Occidental Plateau	06	07N-05W-02	205	13	16	8.26	16.95	213	8-25-93
010904	7600	202-03-026	Occidental Plateau	07	07N-05W-02	159	10	16	8.68	13.80	214	8-25-93
010904	7600	202-03-026	Occidental Plateau	08	07N-05W-02	240	12	20	7.45	17.87	215	8-25-93
010904	7600	202-03-026	Occidental Plateau	09	07N-05W-02	142	14	10	8.20	11.67	216	8-25-93
010904	7600	202-03-026	Occidental Plateau	10	07N-05W-02	122	13	9	10.25	12.48	217	8-25-93
011004	7000	468-02-069	Gunsight Peak	01	26N-13W-30	14	3	5	~	1.16	218	8-23-93
011004	7000	468-02-069	Gunsight Peak	02	26N-13W-30	5	2	3	~	.48	219	8-23-93
011004	7000	468-02-069	Gunsight Peak	03	26N-13W-30	13	1	13	~	.93	220	8-23-93
011004	7000	468-02-069	Gunsight Peak	04	26N-13W-30	23	3	9	~	2.55	221	8-23-93
011004	7000	468-02-069	Gunsight Peak	05	26N-13W-30	53	5	10	~	4.90	222	8-23-93
011004	7000	468-02-069	Gunsight Peak	06	26N-13W-30	92	11	8	~	6.35	223	8-23-93
011006	6400	604-01-020	Alpha Lake	Bulk	30N-19W-32	2909	170	17	6.94	201.85	232	8-12-93

Table 2-WBP Seed Bank

FOR/DIST	ELEV.	STAND	COLLECTION AREA	TREE ID	T-R-S	NO.SEED	NO.CONES	SEED/CONE	G/100	TOTAL GRAMS	LOT	COLL. DATE
011006	6600	653-02-032	25 Mile Crk.	01	28N-14W-14	27	3	9	~	2.41	224	8-18-93
011006	6600	653-02-032	25 Mile Crk.	02	28N-14W-14	171	15	11	7.10	12.11	225	8-18-93
011006	6600	653-02-032	25 Mile Crk.	03	28N-14W-14	14	2	7	~	1.05	226	8-18-93
011006	6600	653-02-032	25 Mile Crk.	04	28N-14W-14	2	3	1	~	0.25	227	8-18-93
011006	6600	653-02-032	25 Mile Crk.	05	28N-14W-14	32	4	8	~	2.09	228	8-18-93
011006	6600	653-02-032	25 Mile Crk.	06	28N-14W-14	72	8	9	~	3.43	229	8-18-93
011006	6600	653-02-032	25 Mile Crk.	07	28N-14W-14	23	4	8	~	1.90	230	8-18-93
011006	6600	653-02-032	25 Mile Crk.	08	28N-14W-14	5	1	5	~	0.13	231	8-18-93
011103	9600	311-04-027	Daisy Pass	01	09S-14E-14	494	12	41	16.74	82.74	4	8-21-91
011103	9600	311-04-040	Daisy pass	BULK	09S-14E-14	6628	113	59	12.07	800.00	3	8-21-91
011103	9600	311-04-027	Daisy pass	BULK	09S-14E-14	5709	108	53	12.26	700.00	4	8-21-91
011103	8700	306-01-040	Palmer Mtn.	BULK	09S-09E-14	5844	126	46	13.69	800.00	5	8-19-91
011103	9100	306-01-036	Palmer Mtn.	BULK	09S-09E-14	5278	95	56	15.45	815.45	1	8-20-91
011103	9600	311-02-097	E. of Henderson	BULK	09S-14E-13	6569	107	61	13.70	900.00	2	8-22-91
011204	7100	417-02-087	Copper Crk.	01	15N-09W-04	111	10	11	17.94	19.94	198	8-31-93
011204	7100	417-02-087	Copper Crk.	02	15N-09W-04	246	15	16	10.13	24.91	197	8-31-93
011204	7100	412-02-087	Copper Crk.	03	15N-09W-04	149	11	14	8.91	13.26	191	8-31-93
011204	7100	417-02-087	Copper Crk.	04	15N-09W-04	307	17	18	10.32	31.65	195	8-31-93
011204	7100	417-02-087	Copper Crk.	05	15N-09W-04	295	16	18	9.72	28.66	199	8-31-93
011204	7100	417-02-087	Copper Crk.	06	15N-09W-04	501	20	25	7.73	38.70	196	8-31-93
011204	7100	417-02-087	Copper Crk.	07	15N-09W-04	216	25	9	10.91	23.53	194	8-31-93
011204	7100	417-02-087	Copper Crk.	08	15N-09W-04	167	11	15	10.60	17.65	192	8-31-93
011204	7100	417-02-087	Copper Crk.	09	15N-09W-04	332	21	16	10.57	35.09	193	8-31-93
011204	7100	417-02-087	Copper Crk.	10	15N-09W-04	301	19	16	12.83	38.65	200	8-31-93
011204	7800	417-02-161	Cotter Mine	01	15N-09W-11	184	10	18	4.04	7.42	174	9-01-93
011204	7800	417-02-161	Cotter Mine	02	15N-09W-11	554	16	35	5.82	32.22	173	9-01-93
011204	7800	417-02-161	Cotter Mine	03	15N-09W-11	386	14	28	6.15	23.76	176	9-01-93
011204	7800	417-02-161	Cotter Mine	04	15N-09W-11	123	10	12	7.02	8.66	178	9-01-93
011204	7800	417-02-161	Cotter Mine	05	15N-09W-11	401	13	31	7.90	31.72	181	9-01-93
011204	7800	417-02-161	Cotter Mine	06	15N-09W-11	395	16	25	6.62	26.13	171	9-01-93
011204	7800	417-02-161	Cotter Mine	07	15N-09W-11	127	8	16	6.13	7.81	185	9-01-93
011204	7800	417-02-161	Cotter Mine	08	15N-09W-11	223	17	13	6.78	15.11	175	9-01-93
011204	7800	416-02-161	Cotter Mine	09	15N-09W-11	179	10	18	6.44	11.50	177	9-01-93
011204	7800	417-02-161	Cotter Mine	10	15N-09W-11	339	15	23	5.27	17.86	190	9-01-93
011204	7600	417-02-161	Lower Cotter Mine	01	15N-09W-11	575	15	38	6.76	38.85	184	9-02-93
011204	7600	417-02-161	Lower Cotter Mine	02	15N-09W-11	636	16	40	8.37	53.23	180	9-02-93
011204	7600	417-02-161	Lower Cotter Mine	03	15N-09W-11	210	19	11	8.91	18.74	189	9-2-93
011204	7600	417-02-161	Lower Cotter Mine	04	15N-09W-11	276	18	15	5.16	14.25	182	9-02-93
011204	7600	417-02-161	Lower Cotter Mine	05	15N-09W-11	315	16	20	6.10	19.20	179	9-02-93
011204	7600	417-02-161	Lower Cotter Mine	06	15N-09W-11	219	12	18	7.21	15.77	187	9-2-93
011204	7600	417-02-161	Lower Cotter Mine	07	15N-09W-11	246	16	15	7.17	17.65	183	9-02-93
011204	7600	417-02-161	Lower Cotter Mine	08	15N-09W-11	626	21	30	7.10	44.48	172	9-2-93
011204	7600	417-02-161	Lower Cotter Mine	09	15N-09W-11	581	29	20	5.81	33.75	188	9-02-93
011204	7600	417-02-161	Lower Cotter Mine	10	15N-09W-11	186	15	12	6.57	12.24	186	9-2-93
011501	7500	104-03-015	Our Lake	01	24N-09W-18	299	12	25	12.67	37.94	20	8-14-92
011501	7500	104-03-015	Our Lake	02	24N-09W-18	226	11	21	12.06	27.28	28	8-14-92
011501	7500	104-03-015	Our Lake	03	24N-09W-18	249	9	28	14.71	36.64	31	8-14-92
011501	7500	104-03-015	Our Lake	04	24N-09W-18	436	10	44	10.98	47.89	35	8-14-92
011501	7500	104-03-015	Our Lake	05	24N-09W-18	213	10	21	15.52	33.04	38	8-14-92
011501	7500	104-03-015	Our Lake	06	24N-09W-18	165	10	17	19.64	32.50	40	8-14-92
011501	7500	104-03-015	Our Lake	07	24N-09W-18	286	11	26	11.34	32.38	43	8-14-92
011501	7500	104-03-015	Our Lake	08	24N-09W-18	334	10	33	11.15	37.22	53	8-14-92
011501	7500	104-03-015	Our Lake	09	24N-09W-18	265	9	29	11.27	29.89	55	8-14-92
011501	7500	104-03-015	Our Lake	10	24N-09W-18	184	10	18	11.27	20.73	79	8-14-92
011501	7500	104-03-015	Our Lake	11	24N-09W-18	340	10	34	13.20	44.91	85	8-14-92
011501	7600	158-03-023	Sheep Shed Mtn.	01	20N-09W-06	224	10	22	12.47	27.88	21	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	02	20N-09W-06	372	10	37	21.92	81.59	27	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	03	20N-09W-06	293	10	29	15.26	44.71	61	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	04	20N-09W-06	551	10	55	10.48	57.70	62	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	05	20N-09W-06	469	10	47	14.88	69.78	63	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	06	20N-09W-06	392	10	39	7.31	28.68	65	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	07	20N-09W-06	538	10	54	14.41	77.53	71	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	08	20N-09W-06	399	10	40	19.93	79.48	94	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	09	20N-09W-06	217	10	22	10.10	21.91	119	8-19-92
011501	7600	158-03-023	Sheep Shed Mtn.	10	20N-09W-06	335	10	34	14.83	49.71	127	8-19-92
011506	8000	624-06-021	Forty crk. (Crazies)	BULK	06N-10E-04	5393	107	50	13.77	742.66	57	8-12-92
011506	8280	624-06-021	Forty crk.(Crazies)	BULK	06N-10E-07	7427	103	72	11.03	819.20	58	8-12-92
011507	8450	706-01-040	Wapiti Peak	BULK	08N-08E-09	3175	154	21	9.45	300.00	6	8-14-91
011507	8450	715-04-062	Wapiti Pk Saddle	BULK	08N-08E-08	2231	144	15	7.78	173.56	7	8-15-91
011603	7000	352-02-023	Cinnebar Pt.	BULK	09N-18W-01	2092	111	19	10.84	226.73	145	8-16-93

Notes

WHITEBARK PINE MONITORING NETWORK

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BACKGROUND

Despite the large and rapid declines in whitebark pine (*P. albicaulis*) stands in its northern range and the probability of large-scale mortality in its southern range in the future, there is no established system for assessing whitebark pine status or trends. While data on whitebark pine stands are beginning to emerge in northern Montana and Idaho (Keane and Arno 1993, Hoff 1992), there is no information on its status in much of the rest of whitebark pine's range. Data on mortality rates and causes and levels of blister rust (*Cronartium ribicola*) infection are essential for developing a management strategy for retaining whitebark pine stands. The case for requesting more support for research and management activities would be strengthened by a clear picture of the range-wide status of whitebark pine.

I propose we develop a whitebark pine monitoring network. Ideally, the network would include stands from throughout whitebark pine's range and would represent all topographic and climatic types. While most sites which have been monitored are located in Montana and Idaho (Fig.1a-d), even there, large gaps occur in coverage. Site information, mortality and rust infection levels and survey dates and methods are summarized in Table 1.

METHODS

A monitoring network needs standard methodology to ensure comparable data. Monitoring objectives should dictate appropriate methods. Here, I present two ways of describing the status of whitebark pine communities. With either method, enough samples should be taken within a stand to be representative of the general condition.

Blister Rust Surveys

Hoff (1992) used a trail segment to survey stands. All seedlings (<6 in dbh) and standing, mature (>6 in dbh) whitebark pine trees within 6 ft and 20 ft, respectively, of each side of the transect were examined. The number of trees in each of the following classes was recorded: blister rust free, rust infected, dead top, dead from rust, dead from unknown causes. Transects were long enough to survey at least 100 individuals in both age classes. This method is a quick way to assess the degree of blister rust infection and mortality in whitebark pine stands.

Ecological Inventory

Keane et al (in press) used 0.10 ac circular plots to gather ecological information from whitebark pine stands. Plots were sampled using ECODATA techniques (Keane et al. 1990, Hann et al. 1989). Information was collected on:

plant community composition, stand age, growth, and crown characteristics, and dead and down woody fuels. Degree of blister rust infection was ocularly estimated for each whitebark pine tree and cause of mortality was determined for all dead trees when possible. Because detailed data is obtained, this method provides information useful for a variety of purposes. Depending on the amount of data collected, it can take 2-4 hrs to complete one plot and thus represents a bigger investment of time than the above survey technique.

RECOMMENDATIONS

To develop a strategy for restoring whitebark pine, we first need to assess condition across its range. I recommend a fast, simple survey like Hoff's. It would fit well with the need to monitor over large areas and would yield estimates of mortality and the degree of rust infection. Such surveys also should include the identification of apparently rust-resistant trees and, if possible, corrected GPS locations for each transect starting point and resistant tree. A more detailed ecological assessment should be done, in addition to geographically extensive surveys, where it is important to learn in more detail, what is occurring in whitebark pine stands and the processes responsible. With that, I would like to open this up to the floor to get input on: 1) is there interest in creating a monitoring network and 2) if so, what goals and methods are appropriate? If there is support for forming a network, I would be willing to coordinate the venture.

LITERATURE CITED

Keane, R.E., P. Morgan, and J. Menakis. [In press]. Landscape assessment of the decline of whitebark pine (*Pinus albicaulis*) in the Bob Marshall Wilderness complex, Montana, USA. Northwest Science.

_____ and S.F. Arno. 1993. Rapid decline of whitebark pine in western Montana: Evidence from 20-year remeasurments. Western Journal of Applied Forestry. 8(2):44-47.

Hoff, Ray. 1992. [Personal communication]. August 17. Moscow, ID: U. S. Department of Agriculture, Forest Service, Intermountain Research Station.

Reinhart, D.P. 1994. [Personal communication]. January 12. U.S. Department of Interior, National Park Service, Yellowstone N.P., WY.

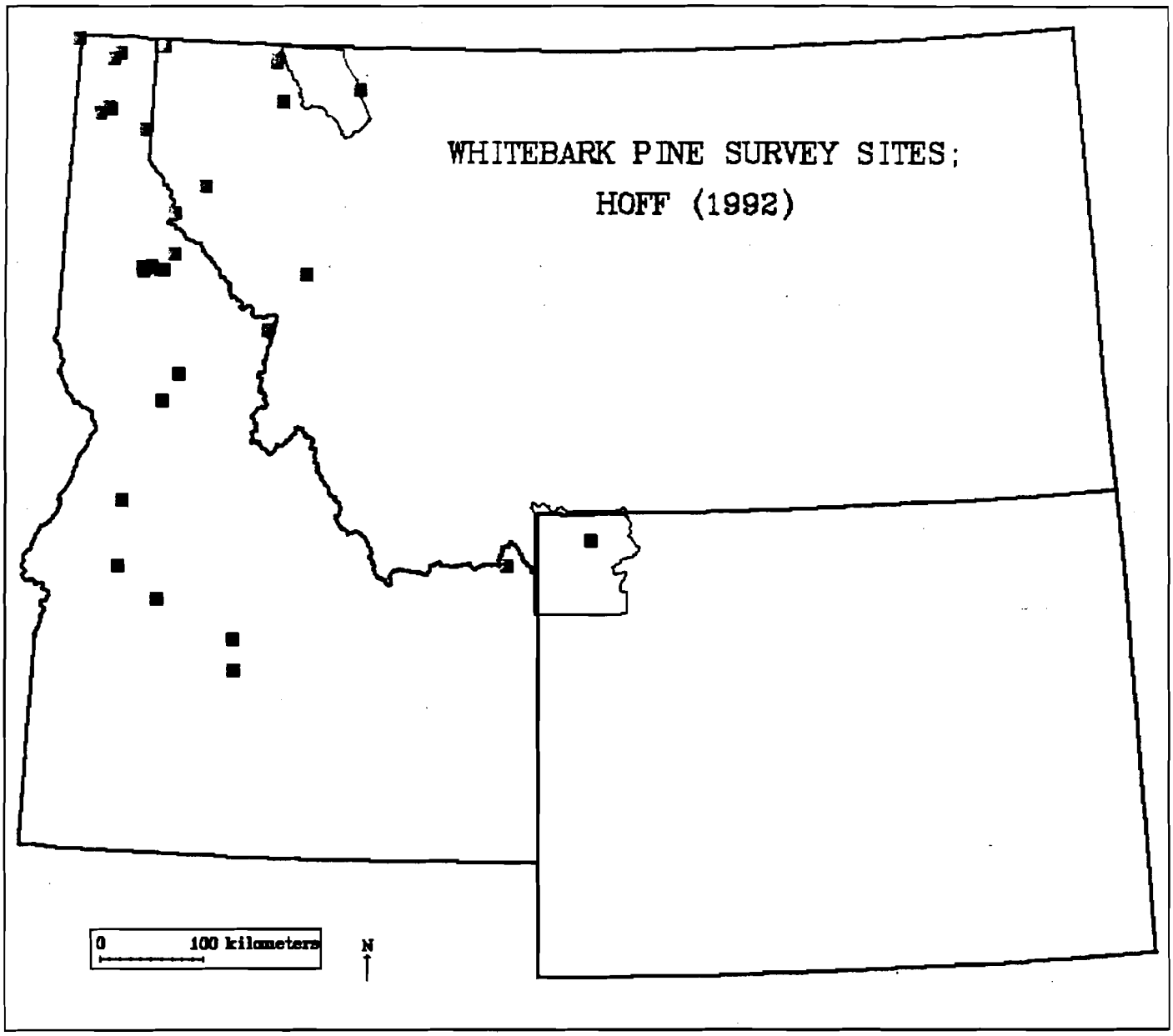


Figure 1a. Whitebark pine survey sites established by Hoff (1992).

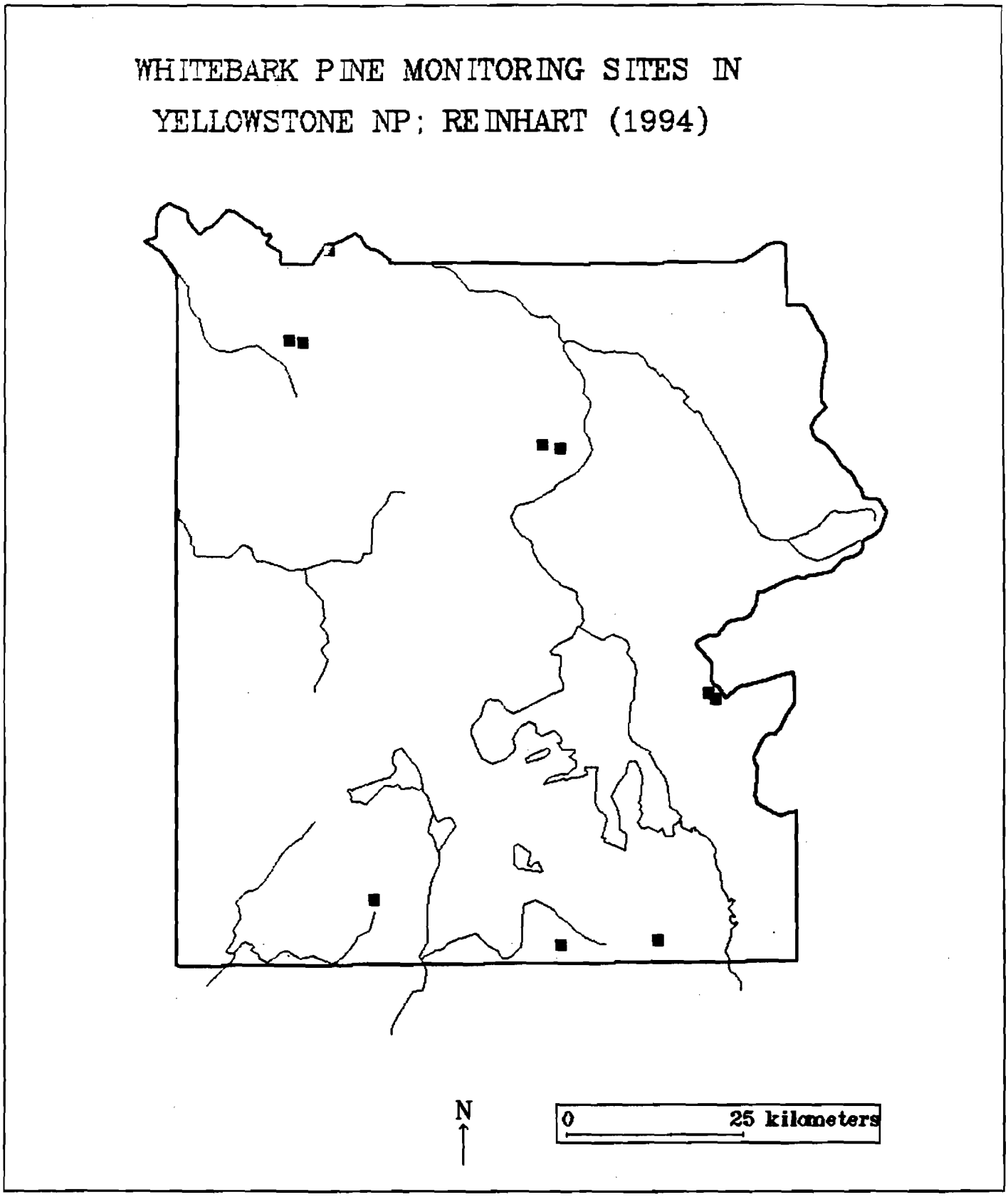
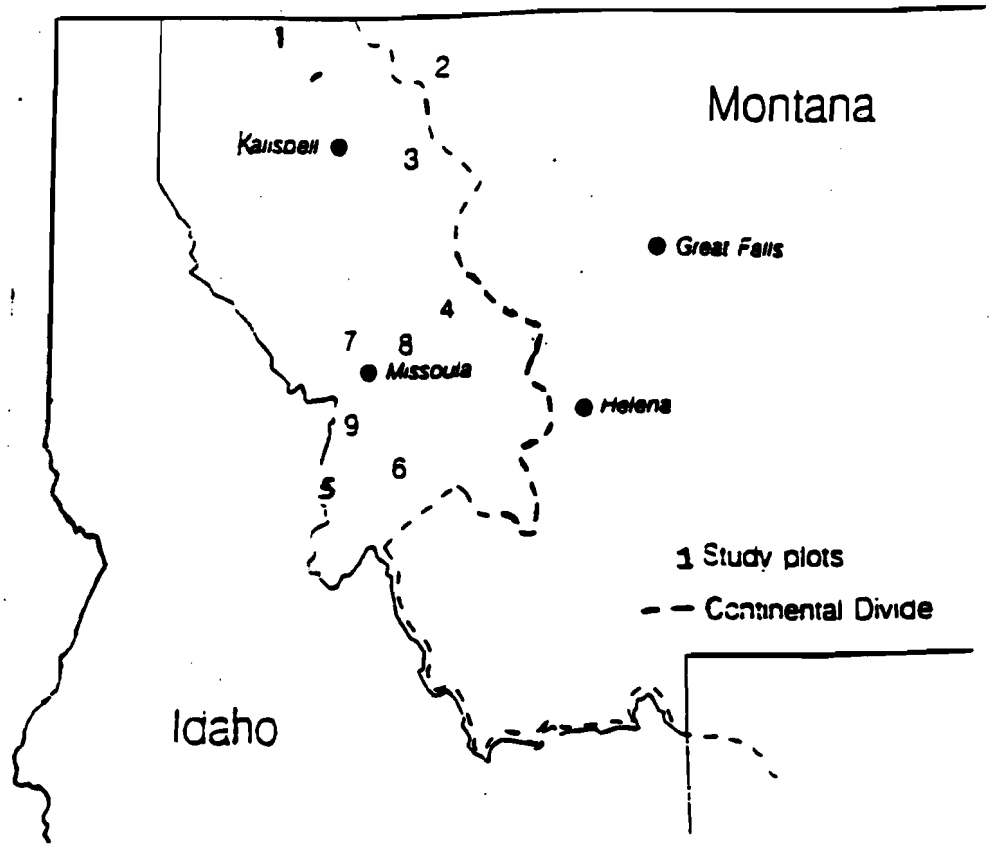


Figure 1b. Whitebark pine monitoring sites established in Yellowstone N.P. (Reinhart 1994).



Location of study areas. 1—Mt. Marston. 2—Divide Mt., 3—25 Mile Creek, 4—Morrell Mt., 5—Twin Lake. 6—Skalkaho Pass. 7—Point Six, 8—Mineral Peak, 9—St. Mary's Peak.

Figure 1c. Whitebark pine study sites established by Keane and Arno (1993).

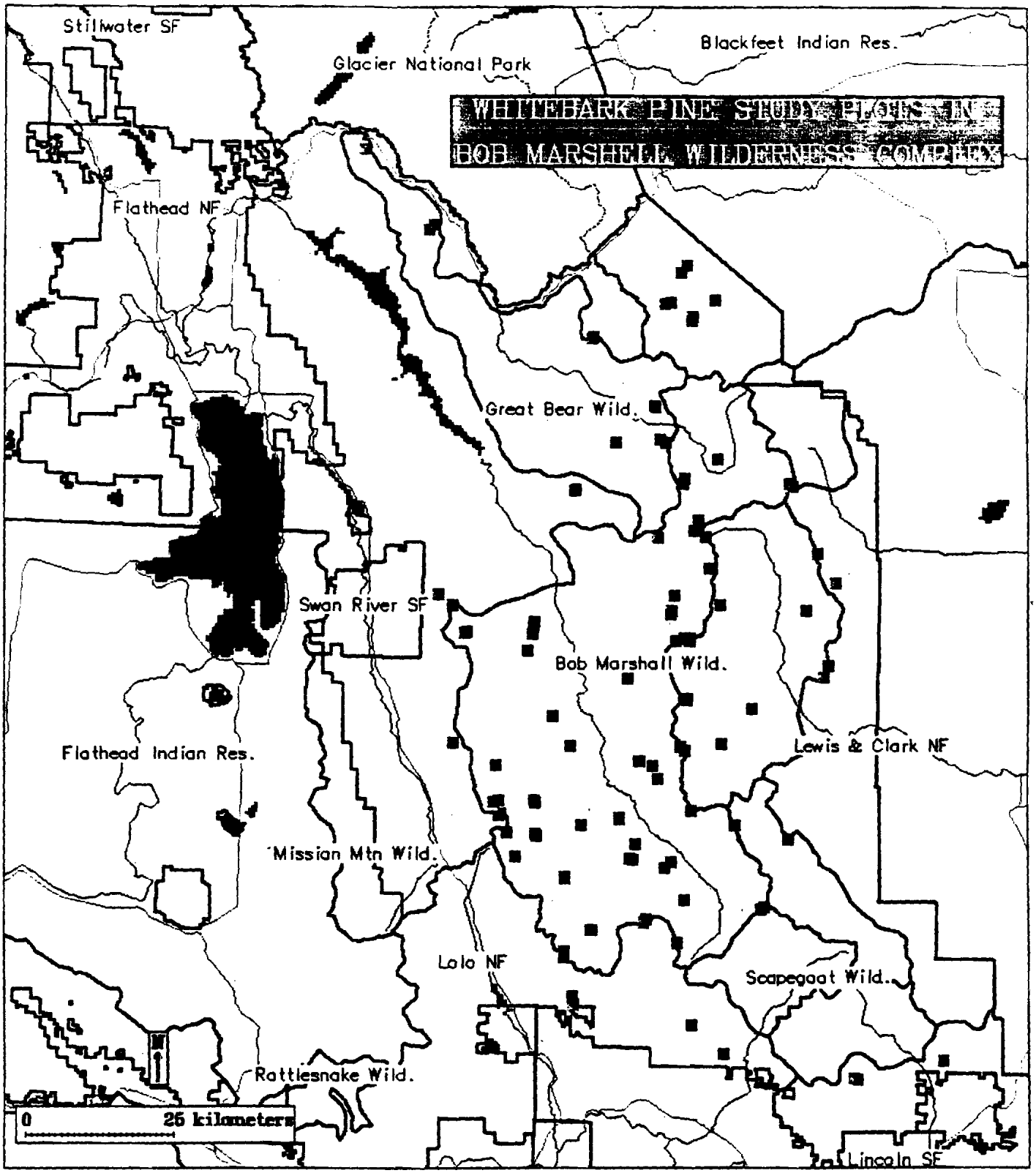


Figure 1d. Whitebark pine study sites established by Keane et al (In press).

Table 1. Whitebark pine mortality and blister rust infection rates at monitoring sites.

Record No.	Site Name, Plot Number	Forest/Park	Coordinates UTM/Lat. Long./ Township, Range	Elevation	Survey Method	% Dead Mature WBP	% Mature WBP infected w/ rust
1	Tioga Pass	Yosemite NP	37 56N 119 16W	9945	Hoff(1992)	0	0
2	Crater Lake	Crater Lake NP	42 55N 122 32W	8025	Hoff	5	47
3	Dollarhide Mountain	Sawtooth	43 36N 114 41W	9301	Hoff	0	0
4	Galena Summit	Challis	43 52N 114 42W	9000	Hoff	0	8
5	Scott Mountain	Boise	44 11N 115 38W	8215	Hoff	0	60
6	Snowbank Mountain 1	Boise	44 27N 116 07W	8273	Hoff	5	17
7	Snowbank Mountain 2	Boise	44 27N 116 07W	7273	Hoff	0	88
8	Sawtell Peak 1	Targhee	44 34N 111 27W	9840	Hoff	0	8
9	Sawtell Peak 2	Targhee	44 34N 111 27W	8758	Hoff	0	24
10	Sawtell Peak 3	Targhee	44 34N 111 27W	8167	Hoff	0	51
11	Mt. Washburn I	Yellowstone NP	44 47N 110 26W	10243	Hoff	0	0
12	Mt. Brundage	Payette	45 01N 116 07W	7216	Hoff	16	76
13	Pilot Knob	Nez Perce	45 54N 115 42W	7135	Hoff	*	†45
14	Coolwater Ridge	Nez Perce	46 08N 115 31W	6929	Hoff	96	100
15	Beaver Ridge	Clearwater	46 33N 114 26W	6580	Hoff	0	31
16	Beaver Ridge Lookout	Clearwater	46 33N 114 26W	7370	Hoff	0	60
17	Sunrise Lodge	Mt. Rainier NP	46 55N 121 38W	6380	Hoff	25	95
18	Freezeout Mountain	St. Joe	47 00N 116 02W	5903	Hoff	0	50
19	Jug Rock	St. Joe	47 01N 115 47W	6437	Hoff	14	86
20	South Butte	St. Joe	47 01N 115 49W	6983	Hoff	22	69
21	Freezeout HCS	St. Joe	47 01N 116 01W	6266	Hoff	83	8
22	Freezeout Ridge	St. Joe	47 01N 116 02W	6266	Hoff	32	53
23	Point Six	Lolo	47 02N 113 59W	7929	Hoff	0	100
24	Crater Peak	St. Joe	47 02N 115 59W	6444	Hoff	18	82
25	Marks Butte	St. Joe	47 02N 116 03W	6297	Hoff	93	2
26	Orphan Point	St. Joe	47 03N 115 56W	6254	Hoff	0	43
27	Middle Sister	St. Joe	47 10N 115 40W	6898	Hoff	40	67
28	Burke Summit	Coeur d'Alene	47 31N 115 42W	6517	Hoff	63	28
29	Vermilion Pass	Lolo	47 46N 115 19W	6026	Hoff	50	53
30	Bee Top Mountain	Kanikso	48 14N 116 08W	6212	Hoff	96	4
31	Gisborne Ridge	Kanikso	48 21N 116 44W	5750	Hoff	83	11
32	Schweitzer	Kanikso	48 23N 116 36W	5552	Hoff	0	44
33	Blue Mountain	Kanikso	48 24N 116 38W	6662	Hoff	9	90
34	Upper Big Creek	Flathead	48 32N 114 23W	6000	Hoff	86	15
35	Divide Mountain	Blackfeet IR	48 40N 113 24W	6300	Hoff	57	77
36	Pyramid Pass 1	Kanikso	48 49N 116 37W	6680	Hoff	0	100
37	Pyramid Pass 2	Kanikso	48 49N 116 37W	7200	Hoff	*	†23
38	Hornet Mountain	Flathead	48 52N 114 30W	6744	Hoff	76	25
39	Fisher Peak	Kanikso	48 52N 116 32W	6673	Hoff	8	97
40	Upper Coal Creek	Flathead	48 57N 114 30W	6000	Hoff	36	78
41	Northwest Peak	Kootennai	48 57N 115 58W	7705	Hoff	52	55
42	Salmo Mountain	Colville	48 58N 117 05W	6828	Hoff	*	†75
43	Deaf Jim Knob	Yellowstone NP	5137 x 49882	8450	Reinhart(1994)	0	0
44	Mt. Washburn I	Yellowstone NP	5438 x 49605	8850	Reinhart	0	0
45	Pitchstone Plateau	Yellowstone NP	5200 x 48960	8600	Reinhart	0	0

* = No mature trees
† = Seedling infection rate
( ) = % Dead Basal Area

46	Fawn Pass I	Yellowstone NP	5100 x 49749	9000	Reinhart	0	0
47	Fawn Pass II	Yellowstone NP	5081 x 49752	8640	Reinhart	0	0
48	Mt. Washburn II	Yellowstone NP	5540 x 49604	9000	Reinhart	0	0
49	Big Game Ridge	Yellowstone NP	5570 x 49870	9700	Reinhart	0	0
50	Two Ocean Plateau	Yellowstone NP	5625 x 49888	9400	Reinhart	0	0
51	Avalanche Peak I	Yellowstone NP	5684 x 49246	8840	Reinhart	0	0
52	Avalanche Peak II	Yellowstone NP	5687 x 49254	9560	Reinhart	0	0
53	Mt. Marston, K110	Kootenai	35N 25W		Keane-Arno(1993)	38(39)	100
54	Mt. Marston, K109	Kootenai	35N 25W		Keane & Arno	33(32)	100
55	Divide Mt, K107	Blackfeet IR	34N 14W		Keane & Arno	63(63)	100
56	Divide Mt., K108	Blackfeet IF	34N 14W		Keane & Arno	80(71)	86
57	25 Mile Creek, K098	Flathead	28N 14W		Keane & Arno	67(48)	100
58	25 Mile Creek, K099	Flathead	28N 14W		Keane & Arno	0	98
59	Morrell, K101	Lolo	17N 14W		Keane & Arno	14(12)	100
60	Morrell, K102	Lolo	17N 14W		Keane & Arno	*	100
61	Morrell, K103	Lolo	17N 14W		Keane & Arno	40(47)	92
62	Twin Lake, K122	Bitteroot	5N 23W		Keane & Arno	0	33
63	Skalkho, K123	Deerlodge	6N 17W		Keane & Arno	20(13)	75
64	Point Six, K117		15N 19W		Keane & Arno	9(6)	100
65	Point Six, K118		15N 19W		Keane & Arno	60(86)	100
66	Point Six, K120		15N 19W		Keane & Arno	67(21)	100
67	Point Six, K119		15N 19W		Keane & Arno	56(65)	100
68	Mineral Peak, K124		14N 17W		Keane & Arno	43(31)	90
69	St. Mary's, K121	Bitteroot	9N 21W		Keane & Arno	67(66)	40
70	Morrell, K001	Lolo	3215 x 52293	7610	Keane et al (in press)	7	100
71	Copper 1, K002	Helena	3695 x 52156	6980	Keane et al	0	41
72	Copper 2, K003	Helena	3688 x 52157	6990	Keane et al	7	100
73	Lake Cr, K004	Lolo	3469 x 52200	6800	Keane et al	8	100
74	Green Mt. 1, K005	Lewis & Clark	3221 x 53147	7190	Keane et al	3	100
75	Green Mt. 2, K006	Lewis & Clark	3223 x 53149	7150	Keane et al	12	94
76	Switchback 1, K007	Flathead	3431 x 53082	7829	Keane et al	1	100
77	Switchback 2, K008	Flathead	3422 x 53078	7200	Keane et al	0	79
78	Pivot 1, K009	Flathead	3559 x 53071	7210	Keane et al	9	100
79	Pivot 2, K010	Flathead	3362 x 53067	7192	Keane et al	4	90
80	Spot Pass 1, K011	Flathead	3415 x 52898	6410	Keane et al	5	39
81	Spot Pass 2, K012	Flathead	3414 x 52895	6600	Keane et al	4	10
82	Larch Hill 1, K013	Lewis & Clark	3406 x 52897	7290	Keane et al	7	36
83	Larch Hill 2, K014	Lewis & Clark	3391 x 52894	7860	Keane et al	1	50
84	Bungalow 1, K015	Flathead	3386 x 52944	8010	Keane et al	3	71
85	Bungalow 2, K016	Flathead	3390 x 52970	7660	Keane et al	2	41
86	Hart Basin 1, K017	Flathead	3448 x 53016	6890	Keane et al	3	20
87	Hart Basin 2, K018	Flathead	3447 x 53016	7020	Keane et al	0	67
88	Pendant 1, K019	Flathead	3094 x 52601	6760	Keane et al	11	100
89	Pendant 2, K020	Flathead	3097 x 52604	6710	Keane et al	0	100
90	Necklace 1, K021	Flathead	3086 x 52624	7060	Keane et al	1	100
91	Necklace 2, K022	Flathead	3092 x 52625	6950	Keane et al	0	100
92	Tango Mt., K023	Flathead	3090 x 52685	6470	Keane et al	0	100
93	Lena Peak 1, K024	Flathead	3155 x 52622	7400	Keane et al	0	91
94	Lena Peak 2, K025	Flathead	3153 x 52625	7550	Keane et al	7	100
95	Koessler Lk, K026	Flathead	3122 x 52521	7018	Keane et al	4	100

* = No mature trees
† = Seedling infection rate
( ) = % Dead Basal Area

96	Cardinal 1, K027	Flathead	3204 x 52498	7010	Keane et al	0	100
97	Cardinal 2, K028	Flathead	3203 x 52493	7432	Keane et al	0	96
98	Shaw Mt. 1, K029	Flathead	3154 x 52569	6797	Keane et al	0	100
99	Shaw Mt. 2, K030	Flathead	3156 x 52565	6658	Keane et al	0	91
100	Gordon Pass, K031	Flathead	3106 x 52572	6937	Keane et al	2	100
101	Pyramid 1, K032	Lolo	3212 x 52364	6770	Keane et al	6	100
102	Pyramid 2, K033	Flathead	3202 x 52372	6970	Keane et al	3	100
103	Crimson 1, K034	Flathead	3246 x 52476	7400	Keane et al	1	93
104	Crimson 2, K035	Flathead	3249 x 52408	7167	Keane et al	13	100
105	Gordon Mt. 1, K036	Flathead	3317 x 52526	6890	Keane et al	0	0
106	Gordon Mt. 2, K037	Flathead	3312 x 52528	7189	Keane et al	0	70
107	Hahn Pass 1, K038	Flathead	3337 x 52420	6790	Keane et al	2	91
108	Hahn Pass 2, K039	Flathead	3340 x 52427	6405	Keane et al	1	100
109	Grace Mt., K040	Flathead	3406 x 52459	6895	Keane et al	1	50
110	Jumbo 1, K041	Flathead	3371 x 52513	7810	Keane et al	6	95
111	Jumbo 2, K042	Flathead	3382 x 52522	6646	Keane et al	1	30
112	Camp Creek, K043	Flathead	3417 x 52608	7130	Keane et al	8	40
113	Obs. Point 1, K044	Flathead	3539 x 52447	8163	Keane et al	6	40
114	Obs. Point 2, K045	Flathead	3533 x 52443	7585	Keane et al	10	33
115	Headquarters, K046	Lewis & Clark	3660 x 52989	6321	Keane et al	1	47
116	Beartop, K047	Lewis & Clark	3610 x 52944	7790	Keane et al	16	100
117	Sock Lake, K048	Lewis & Clark	3467 x 52953	6790	Keane et al	0	0
118	Route Creek, K049	Lewis & Clark	3601 x 53038	7100	Keane et al	2	100
119	Arsenic Mt., K050	Lewis & Clark	3648 x 52853	7290	Keane et al	6	100
120	Circle Creek, K051	Lewis & Clark	3609 x 52833	7130	Keane et al	0	50
121	Sheep Mt., K052	Lewis & Clark	3520 x 52780	6706	Keane et al	3	0
122	Inspiration 1, K053	Flathead	2994 x 52971	7000	Keane et al	9	100
123	Inspiration 2, K054	Flathead	3018 x 52953	7126	Keane et al	23	100
124	Sunburst 1, K055	Flathead	3042 x 52910	6740	Keane et al	5	100
125	Sunburst 2, K056	Flathead	3037 x 52908	7510	Keane et al	5	100
126	Picture N1, K057	Flathead	3154 x 52923	7500	Keane et al	22	96
127	Picture N2, K058	Flathead	3151 x 52918	7580	Keane et al	9	95
128	Picture S1, K059	Flathead	3151 x 52906	7310	Keane et al	5	92
129	Picture S2, K060	Flathead	3142 x 52878	7515	Keane et al	3	93
130	Garnet Peak, K061	Flathead	3184 x 52767	6888	Keane et al	6	56
131	Charlotte Pk, K062	Flathead	3123 x 52716	7450	Keane et al	6	72
132	Butcher 1, K063	Flathead	3294 x 52596	7150	Keane et al	3	90
133	Butcher 2, K064	Flathead	3293 x 52594	7150	Keane et al	6	100
134	Shale Mature, K065	Flathead	3359 x 52661	7820	Keane et al	0	100
135	Shale Seral, K066	Flathead	3360 x 52662	7820	Keane et al	0	100
136	Tilison Ridge, K067	Flathead	3352 x 52683	7648	Keane et al	14	94
137	Tilison Mat, K068	Flathead	3330 x 52690	7350	Keane et al	1	77
138	Tilison Seral, K069	Flathead	3329 x 52691	7320	Keane et al	7	100
139	Pilot Ridge, K070	Flathead	3323 x 52551	8020	Keane et al	5	76
140	Una Basin, K071	Flathead	3232 x 52584	8030	Keane et al	0	88
141	Chair Ridge, K072	Flathead	3365 x 53235	7015	Keane et al	2	100
142	Gable Peak, K073	Flathead	3375 x 53229	7050	Keane et al	3	100
143	Capitol Ridge, K074	Flathead	3290 x 53229	6433	Keane et al	5	100
144	Lodgepole 1, K075	Flathead	3355 x 53290	7002	Keane et al	24	100
145	Lodgepole 2, K076	Flathead	3357 x 53287	6890	Keane et al	7	100

* = No mature trees
† = Seedling infection rate
( ) = % Dead Basal Area

146	Trilobite 1, K077	Flathead	3406 x 53168	6935	Keane et al	0	100
147	Trilobite 2, K078	Flathead	3405 x 53159	6840	Keane et al	2	100
148	Slideout Mt., K079	Flathead	3462 x 53201	7180	Keane et al	4	100
149	Teton Pass 1, K080	Lewis & Clark	3582 x 53158	6740	Keane et al	0	100
150	Teton Pass 2, K081	Lewis & Clark	3588 x 53153	7437	Keane et al	3	100
151	White River 1, K082	Lewis & Clark	3400 x 52716	7650	Keane et al	3	90
152	White River 2, K083	Lewis & Clark	3406 x 52709	7854	Keane et al	0	0
153	Cliff Mt. Mat, K084	Lewis & Clark	3410 x 52796	7140	Keane et al	5	100
154	Cliff Mt. Ser, K085	Lewis & Clark	3410 x 52794	6900	Keane et al	0	100
155	Prairie Reef, K086	Lewis & Clark	3469 x 52721	7028	Keane et al	6	100
156	Owl Ridge 1, K087	Lewis & Clark	3384 x 53463	6520	Keane et al	5	90
157	Owl Ridge 2, K088	Lewis & Clark	3373 x 53460	6840	Keane et al	7	83
158	Halfdome, K089	Lewis & Clark	3459 x 53467	6940	Keane et al	13	100
159	Goat Mt. 1, K090	Lewis & Clark	3419 x 53433	7550	Keane et al	17	94
160	Goat Mt. 2, K091	Lewis & Clark	3420 x 53440	6715	Keane et al	7	100
161	Whiterock 1, K092	Lewis & Clark	3401 x 53513	6440	Keane et al	17	100
162	Whiterock 2, K093	Lewis & Clark	3410 x 53525	7001	Keane et al	15	100
163	Ouzel Mt. Mat, K094	Flathead	2867 x 53719	6935	Keane et al	6	100
164	Ouzel Mt. Ser, K095	Flathead	2868 x 53719	6921	Keane et al	0	0
165	Grant Ridge 1, K096	Flathead	2987 x 53592	6580	Keane et al	5	100
166	Grant Ridge 2, K097	Flathead	2978 x 53585	6728	Keane et al	3	100
167	25 Mile Creek 1, K098	Flathead	3252 x 53404	6641	Keane et al	10	100
168	25 Mile Creek 2, K099	Flathead	3253 x 53405	6520	Keane et al	1	90
169	Smith Cr Pass, K100	Flathead	3017 x 52723	7347	Keane et al	17	100
170	Morrell Pk 1, K101	Lolo	3215 x 52297	7930	Keane et al	8	100
171	Morrell Pk 2, K102	Lolo	3216 x 52297	7830	Keane et al	0	100
172	Morrell Pk 3, K103	Lolo	3217 x 52284		Keane et al	7	92
173	Silver King, K104	Helena	3840 x 52188	7651	Keane et al	4	100
174	Spread Mt., K105	Lolo	3416 x 52248	7910	Keane et al	10	100
175	Patrol Mt., K106	Lewis & Clark	3578 x 52560	7530	Keane et al	4	100
176	Limestone Pass, K111		3394 x 52386		Keane et al	8	96
177	Pagoda Mt., K112		3490 x 52583	7000	Keane et al	1	80
178	Pagoda Mt., K113		3311 x 52833		Keane et al	0	50
179	Bungalo So, K114		3383 x 52937		Keane et al	1	58
180	Dean Lake, K115		3431 x 53096	7280	Keane et al	0	100
181	Kevar Mt., K116		3443 x 53070	7015	Keane et al	3	100

* = No mature trees
† = Seedling infection rate
( ) = % Dead Basal Area

POSTER SESSION TITLES AND PARTICIPANTS

"Differentiation of Whitebark and Western White Pine"

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"Subalpine Fire and Forest Patterns on the Bitterroot National Forest"

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"The Wheeler Creek Prescribed Burn - Post-fire Whitebark Regeneration"

Bob Keane (S22L01A), Mike Jensen, Wally Bennett, and Dave Bunnell
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"Response of Vegetation to Burning in a Whitebark Pine Community, Bob Marshall Wilderness, Montana"

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"Latest Technics in Growing Containerized Whitebark Pine at Coeur d'Alene Nursery"

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"Aerial Sketchmapping as an Inventory Tool for Landscape Analysis in Whitebark Pine Ecosystems"

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"Region Six Genetic Resource Program - Roles in Ecosystem Management"

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"Proposed Investigation of Whitebark Pine Mycorrhizae"

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"Tenderfoot Creek Experimental Forest - A Demontration Forest for Ecosystem Management Concepts"

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DIFFERENTIATION OF WHITEBARK AND WESTERN WHITE PINE

Poster by Ray J. Hoff

Ranges of whitebark and western white pine frequently overlap. Mature trees are quite easy to differentiate because of general morphological differences and of course the cones are very different. However, with young trees, up to 8 feet tall or so, there is an overlap in morphology. Nonetheless, there is a good way to tell them apart. Whitebark pine has from 1 to 4 rows of stomates in the abaxial side of the needle. The abaxial side is the rounded outer side. In western white pine there are just a few stomates at the tip of the needle. This difference was reported by Dunwiddle (1985, Northwest Science); but just like all other biological characters this trait varies.

The following data illustrates some of this variation.

WHITEBARK PINE

Area	Stands	Families	Seedlings	Needles	Mean Rows at Center	Range
	#	#	#	#	#	#
Idaho/ Montana	9	39	741	921	1.8	0-4

The rows of stomates for whitebark pine are present from the tip to the base of the needles. There were only two needles that had no stomates on the abaxil side, however, there were stomates row(s) on the other four needles within the same fascicle.

WESTERN WHITE PINE

Area	Stands	Families	Needles	Mean Length of Fascicle	Length of Longest Stomate Row	
					Mean	Range
	#	#	#	mm	mm	mm
Montana	4	20	100	78	1.5	0-4
Idaho	9	48	240	82	2.3	0-22
British Columbia	5	22	110	81	1.9	0-9
Washington	9	16	80	81	1.6	0-14
Oregon	12	44	220	82	5.5	0-68
California	8	30	150	61	14.6	0-45

The rows of stomates in western white pine were measured from the tip of the needle. None of the needles from Montana, Idaho, British Columbia and Washington had stomates even close to the middle of the needle and can be easily

differentiate from needles of whitebark pine. Even for the longest stomata row (22 for Idaho) the stomata row occurred in the top quarter of the needle.

However, there were three stands of white pine in Oregon and five stands in California that had at least one row of stomates that went from the tip past the center of the needle. Nonetheless, the basal one-quarter to one-third of these needles did not have stomates. So, for California and parts of Oregon, differentiation can be made by looking at the basal portion the needle; assuming of course that the stomate situation for whitebark pine is the same in that part of its range as it is in the northern area. Isn't biodiversity fun.

Forest Structure and Landscape Patterns in the Subalpine Lodgepole Pine Type: A Procedure for Quantifying Past and Present Conditions

Stephen F. Arno
Elizabeth D. Reinhardt
Joe H. Scott

INTRODUCTION

In the lodgepole pine/subalpine fir forests of the Northern Rocky Mountains, fires and mountain pine beetle outbreaks have recurred for thousands of years. Each disturbance began a new cycle of succession and new landscape patterns (Lotan and others 1985). Recently, National Forest managers have attempted to assess the effects of fire suppression and logging on landscape patterns and wildlife habitat in these forests. Lodgepole pine forests have experienced a diverse history of disturbance, and succession has occurred over different time scales (Arno 1980; Barrett and others 1991; Hawkes 1979; Romme and Despain 1989; Tande 1979). Thus, site-specific information is necessary to describe landscape patterns and change. Preliminary maps of stand mosaics can be prepared from aerial photographs. However, field inspections and inventories are needed to refine these maps and to accurately characterize a stand's structure and its history of disturbance.

We have developed a method for documenting forest structure and landscape patterns. To test the method, we conducted a pilot study of a 500-acre tract of lodgepole pine/subalpine fir forest on a broad, subalpine ridge in the Bitterroot National Forest southwest of Hamilton, MT. We used this experience to develop a procedure for quantifying forest structure and landscape patterns—both past and present—in other subalpine lodgepole pine forests. Along with the proposed sampling procedure, we offer suggestions for analyzing and interpreting data. We began with the procedures presented in Arno and Sneck (1977) and Barrett and Arno (1988), refining and expanding them to characterize the landscape mosaic quantitatively. A three- to four-person crew spent 5 days sampling during our pilot study. We laid out a grid of transects, systematically sampling 35 different 0.1-acre plots spaced 800 feet apart. The data revealed a surprisingly complex mosaic of forests stands linked to disturbance history as well as a pronounced successional advance toward climax forest conditions during this century.

RECOMMENDED FIELD METHODS

This technique is best suited to continuously forested areas from about 500 to 2,000 acres in size, with moderate, rather than steep and broken, terrain. If landscape patterns are being defined over larger areas, this technique might be used to sample representative portions of the areas. The technique was designed for and tested in the subalpine lodgepole pine zone, although it might be useful in some other disturbance-related (seral) forest types. Often, aerial photographs are used to look for mosaic patterns based on the structure of forest stands. But if moderate-intensity fires have occurred, the stand mosaic is probably more intricate than it might appear from the photographs. Timber type maps or other stand maps may also give a general overview of the most obvious stand mosaic patterns in the area. A 4-inch-per-mile topographic map (such as a 150 percent photocopier enlargement from a 7-½ minute U.S. Geological Survey quadrangle) is convenient for delineating the study area.

The next step is to determine the distance between plots, and the corresponding number of plots. We recommend setting up a grid in which the distance between plots along a transect is the same as the distance between transects (fig. 1). The plot grid should be fine enough to allow mapping at the desired level of resolution. Plot spacings between 500 and 1,000 feet will probably be appropriate for characterizing stand mosaic patterns. A grid should contain at least 35 to 40 plots to depict and quantify a landscape mosaic for a small area. To determine a useful spacing for the systematic grid, divide the total area by a proposed number of plots. This will indicate the number of acres represented by each plot. For example, 500 acres divided by 34 plots equals 14.7 acres/plot, which corresponds to a square spacing of 800 feet—the square

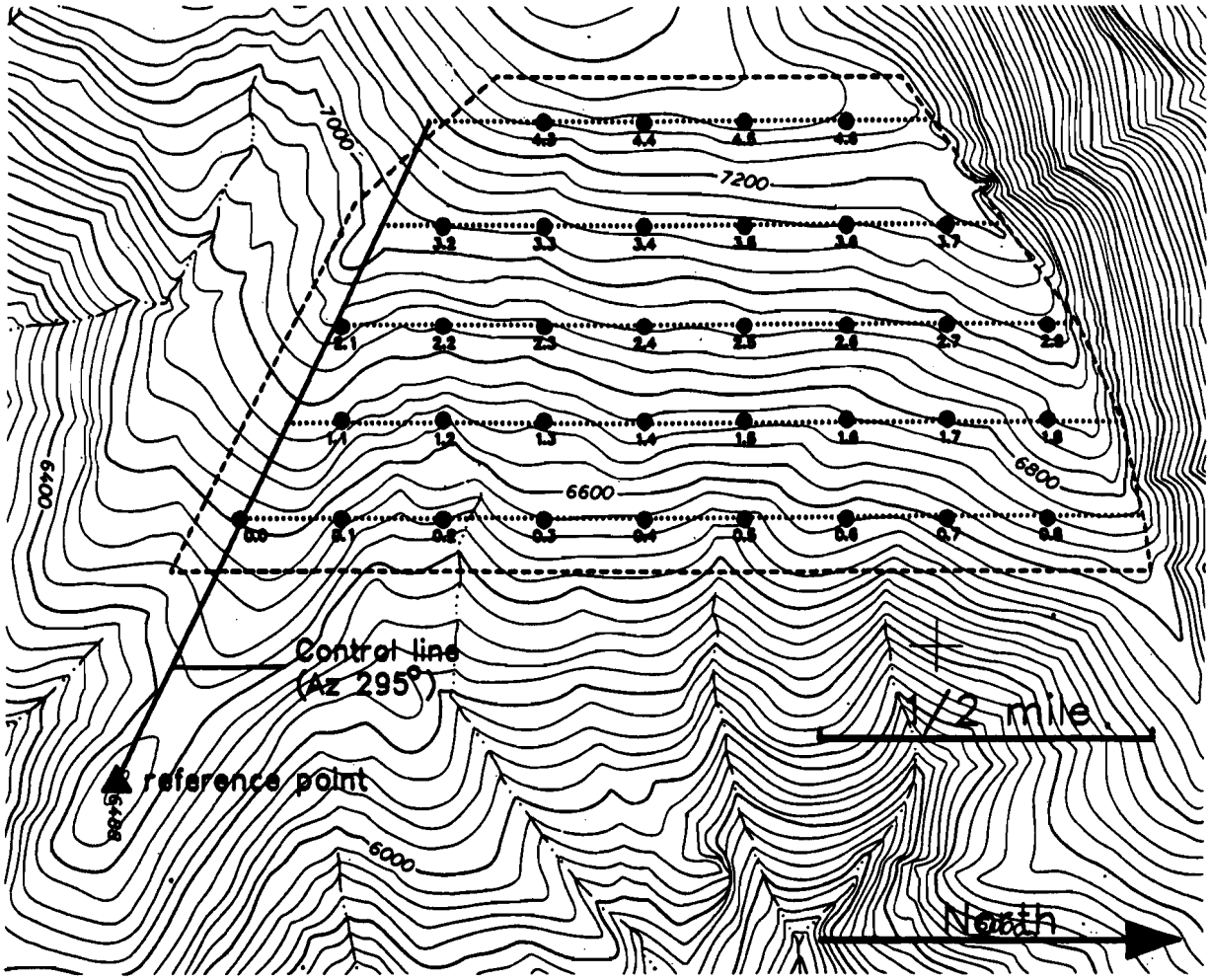

Figure 1—Layout of the systematic grid of sample points in the Lick Creek Headwaters study area (delineated by dashed line). Sample plots (solid circles) are labeled with the transect number and grid point on that transect. The control line (solid line) should be established first, so that each transect (dotted lines) can start on the control line. (Note that the terrain prevented the control line from being perpendicular to the transects and that the study area excluded steeper terrain nearby.)

root of the quantity 14.7 acres times 43,560 square feet per acre. On a 4-inch-per-mile base map this ground distance is represented by 0.61-inch map distance (800 feet/5,280 feet/mile x 4 inches/mile = 0.61 inch). A three- to-four-person crew will take about an hour to sample each plot, including the time to lay out the transect to the next plot.

When the proposed number and spacing of plots has been selected, the plot grid can be overlaid on the study area base map (see fig. 1). The plot locations are found by measuring the predetermined distances between plots. Accurate information on stand boundaries is gathered by recording the points on each transect where stand boundaries are crossed. Transects can be laid along the topographic contours so the sample points are at roughly the same elevation. The study area's shape and topography will influence the grid's design and position. The actual number of plots may differ slightly from the proposed number.

Laying Out a Grid

The procedure for establishing a grid of sample points is similar to that used in the line-plot method of timber cruising (see Dilworth 1989 or Society of American Foresters 1984). An important difference for this procedure is that the location of each sample point must be determined and mapped by reference to a landmark near the area to be sampled.

Begin by locating a geographic feature that can be located both on a map and on the ground, such as a rock outcrop, road junction, or section corner (fig. 1). On the map, draw a primary control line starting at this reference point. If possible, run this line perpendicular to the desired transect orientation. Systematically draw the transect lines (secondary control lines in a line-plot timber cruise) at the predetermined horizontal distance between transects. For uniform sampling coverage, locate the first transect line one-half

the distance between transects inside the study area boundary. Each succeeding transect is drawn parallel to the first at the prescribed distance until the sample area is fully covered.

Next, draw markers on the map indicating sample point locations. Locate the first plot at the intersection of the control line and the first transect, provided this plot falls within the study area. Locate each successive plot on the transect at the predetermined distance, the same as the distance between transects. After you have located all the plots, you will have drawn an aligned grid (fig. 1).

Figure 1 shows a grid layout that runs along the contours of an east-facing watershed. In this case, an east-west control line could not be established perpendicular to the transects due to the steep, broken terrain, and the lack of reference points. Instead, the control line was started at the monument on peak 6488 and drawn along the ridge near the study area's southern boundary. The resulting line had a map-measured true azimuth of 295 degrees, forming an angle of 65 degrees with the north-south transect lines. The prescribed transect interval was 800 feet, so the distance between transects along the control line was 800 feet divided by the sine of 65 degrees (0.906), or 883 feet. The corresponding map distance is 0.69 inch on a 4-inch-per-mile map.

When you are working in the field, you can use a compass, clinometer, and 300-foot surveyor's tape to measure from the reference point to the intersection of the control line and the first transect. All measurements and calculations are for horizontal distance, so take care to hold the tape horizontal or to correct for slope while taping by using a table of slope correction factors or a similar method. Establish the entire control line, placing a wire flag at the start of each transect (every 883 feet in fig. 1). Write the transect number on the flag with a permanent marker. Sample the first plot at the intersection of the control line and the first transect (fig. 1). After sampling this plot, continue measuring along the first transect to successive predetermined sample points.

Sample succeeding transects in the same manner. However, unless the control line is perpendicular to the transects, you will need to determine the distance from the flag at the start of the transect to the location of the first plot. To make the calculation in the example (fig. 1), determine the distance traveled north by dividing 800 feet by the tangent of 65 degrees (2.145) to get 373 feet. That is, in traveling 883 feet at an azimuth of 295 degrees, you moved 373 feet north. Therefore, you only need to travel 800 – 373 or 427 feet to arrive at the first plot north of the flag on the second transect. Depending on the shape of the area, plots might be located on both sides of the control line. By the fourth transect you will have traveled 373 x 4 or 1,119 feet north of the first plot established. Since you will now be north of the second plot of the grid, the distance to the next plot on the transect is 1,600 – 1,119 or 481 feet.

Plot Sampling Procedure

At each predetermined point, place a wire flag in the ground, labeled with the transect and plot number. This flag will be the center of the 0.1-acre circular plot (37.2-foot radius). Use an inventory form (appendix B) to record site characteristics, including elevation, aspect, and percent slope. Examine the vegetation in the plot and determine the habitat type and phase in the applicable classification—in Montana, Pfister and others (1977).

Tally all living trees in the plot by species and diameter-size classes (appendix B). The plot can be tallied in pie-shaped segments using 37.2-foot cables or ropes staked at the plot's center, extending out like spokes on a wheel.

Examine the plot for evidence of the previous stand. Describe any previous overstory layer that is now dead, listing the major species and the diameter of these trees. Try to determine whether this layer was the dominant overstory, or was scattered. This former overstory may be standing or lying on the forest floor. Try to determine why and roughly when the overstory trees died. For example, lodgepole pine stands often have a major component of large lodgepole or whitebark pine trees that were killed by beetles in the early 1900's. You may find galleries where the beetles lived etched in the trunks of dead trees. Or you may find evidence of a fire intense enough to destroy the stand. The previous stand may still be evident as dead trees, either down or standing. The dead trees may have remnants of charred bark, but the wood itself will not be charred. Other stands may have arisen after a double burn, which consumed most remnants of the previous stand; still, you should be able to find charred stumps from the trees killed by the first burn. Note how this information is recorded in appendix B.

Record fire history evidence in and adjacent to the plot. For instance, identify trees with single, double, or multiple fire scars, and determine the best scars to sample by cutting out a section with a saw, as described in Arno and Sneck (1977). You should saw fire scar sections while sampling plots, for greatest efficiency and to aid field interpretation.

We have found that a light-weight 2.7-cubic-inch chain saw with a 16-inch bar (weight 12 pounds without fuel) is usually adequate for fire scar sampling in most lodgepole pine stands. A 3.5-cubic-inch saw with a 20-inch bar is usually adequate for sectioning larger fire-scarred trees, such as Douglas-fir. Where sawing is not allowed, increment borers can be used to sample fire scars (Barrett and Arno 1988), although this method is less precise and takes more time.

The final step in sampling is to obtain accurate age-class data to characterize stand structure. For example, lodgepole pine forests generally have even-aged classes of the shade-intolerant (seral) species—lodgepole pine, western larch, and perhaps whitebark pine. These species usually became established soon after fires. In contrast, shade-tolerant species such as spruce, subalpine fir, and interior Douglas-fir, regenerate successfully without disturbances such as fires. Accurately identifying the age-classes of seral species helps determine the influence past fires have had on forest composition and stand structure. If the stand has living trees with single fire scars and the fire was severe enough to kill some trees and open the stand, the stand should have a postfire age class along with one or more age classes of the fire's survivors. If the stand does not have living fire-scarred trees, there is likely to be just one age class of seral trees—the class that began growing after the last stand-replacement fire.

To learn the stand's fire history, use an increment borer to age four to six seral trees representing the old, or fire-scarred, generation. Similarly, sample a few seral dominant trees that appear to be from the postfire generation. In each case, bore the tree within a foot of ground line. You need to continue boring until you obtain a sample that intersects or passes very near the pith. Large trees can be bored higher on the bole, if necessary to avoid rot; then a correction factor must be developed to account for the years the tree took to grow to the height at which the core was taken. These and other age-class sampling procedures are described in more detail in Barrett and Arno (1988).

Make a preliminary growth-ring count of all sample trees while you are in the field so you will know when you have adequately sampled all age-classes. You may find individual rings difficult to distinguish during slow-growth periods. Wetting the core with water and using a 10-power hand lens when reading it may help. Some segments with extremely slow growth, where rings are close together, may have to be sliced with a single-edged razor blade before you can read them.

Five or more seral trees with similar ages constitute good evidence of a disturbance-induced regeneration age class. Data from nearby plots can help confirm age classes. If fire records are unavailable, or fire scars are not found, the establishment date of the oldest tree in a fire-initiated age class provides the best indicator of the fire year. Even so, the fire may have occurred several years earlier.

A few borings should be taken from the largest shade-tolerant trees in the plot (for example, spruce or subalpine fir) to augment the information on age-class structure. Spruce occasionally survive light fires. Subalpine fir seldom do unless they were in a patch of unburned trees. Large Douglas-firs often survive fires and have healed-over fire scars as evidence (Arno and Sneck 1977; Barrett and Arno 1988).

Since field counts are imprecise, you should label and store the cores in straws or mount them in grooved boards so you can make the final determinations of age in the office or laboratory (Barrett and Arno 1988). When measuring along the transect to the next plot, record the boundary of habitat-type changes and stand-type changes. In most cases, you will sample the newly encountered stand type at the next plot.

DATA SYNTHESIS

Our method allows a landscape mosaic grid to be developed. Each grid point is a mosaic element, helping to define the stand's history of disturbance, and its composition and structure. The data can be used to reconstruct presettlement stand conditions, allowing the current landscape to be compared with a primeval landscape.

After you have collected the field data and determined tree ages, record the disturbance history at each sample plot, using the data form in appendix C. Use the fire scar dates and age classes of seral trees (lodgepole pine in this case) to characterize the stand history in each plot. Additional disturbances that did not result in seral age classes, such as underburns or beetle epidemics, should also be recorded.

The tree diameter data associated with each age class indicate the presence and abundance of a given age class in each sample plot. You should try to link each age class to a diameter class at each plot. Sometimes diameters associated with two different age classes overlap. Trees in the older age class will often have a visible fire scar or crown form typical of older (overmature) trees. In sample plots where such overlaps are a serious problem, you can use fire scars, crown form, or even increment borings from individual trees to determine the age class of each seral tree in the sample plot. Some stands may not have enough evidence to date fires or other major disturbances—for example see figure 2, third sample from the left in the lower row. In other stands, several minor disturbances may have given rise to mixed age classes—for example, figure 2, lower right sample.

For each sample plot, the age-class structure of the seral stand components can be described for the current stand and also estimated for the stand as it existed in the past. In this study we used 1900 as a comparison year. We felt that it would have been difficult to speculate about stand conditions before then, and that 1900 was early enough to represent an essentially unmanaged landscape. In other study areas, a different comparison year might be chosen. We noted the presence in the two time periods of any structural classes of seral tree species, represented as seedlings, saplings, poles, mature or overmature trees, based on their ages. The age class criteria we used are listed in figure 3; modifications might be needed for other sites.

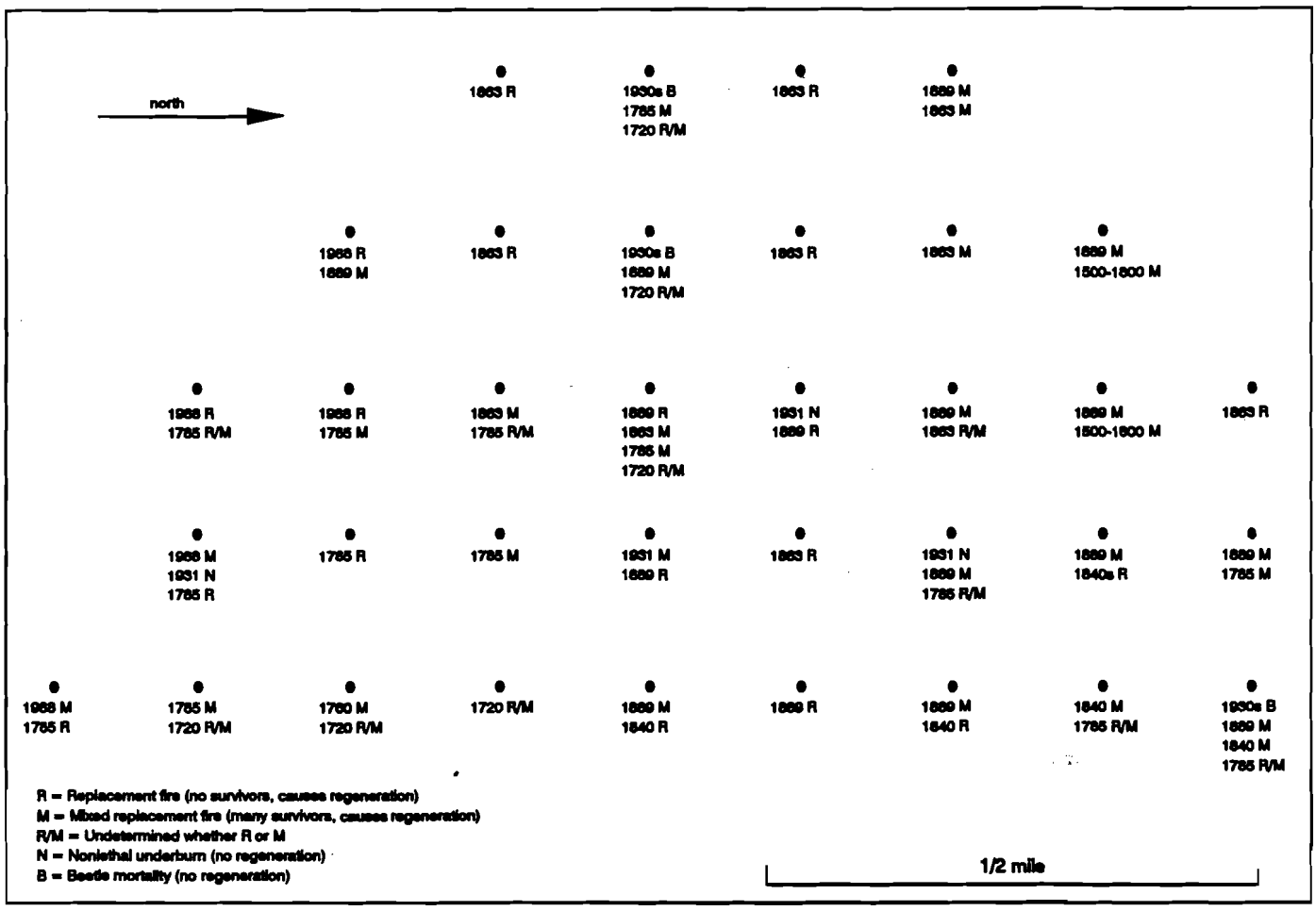

Figure 2—Disturbance history at each sample plot in the Lick Creek Headwaters study area.

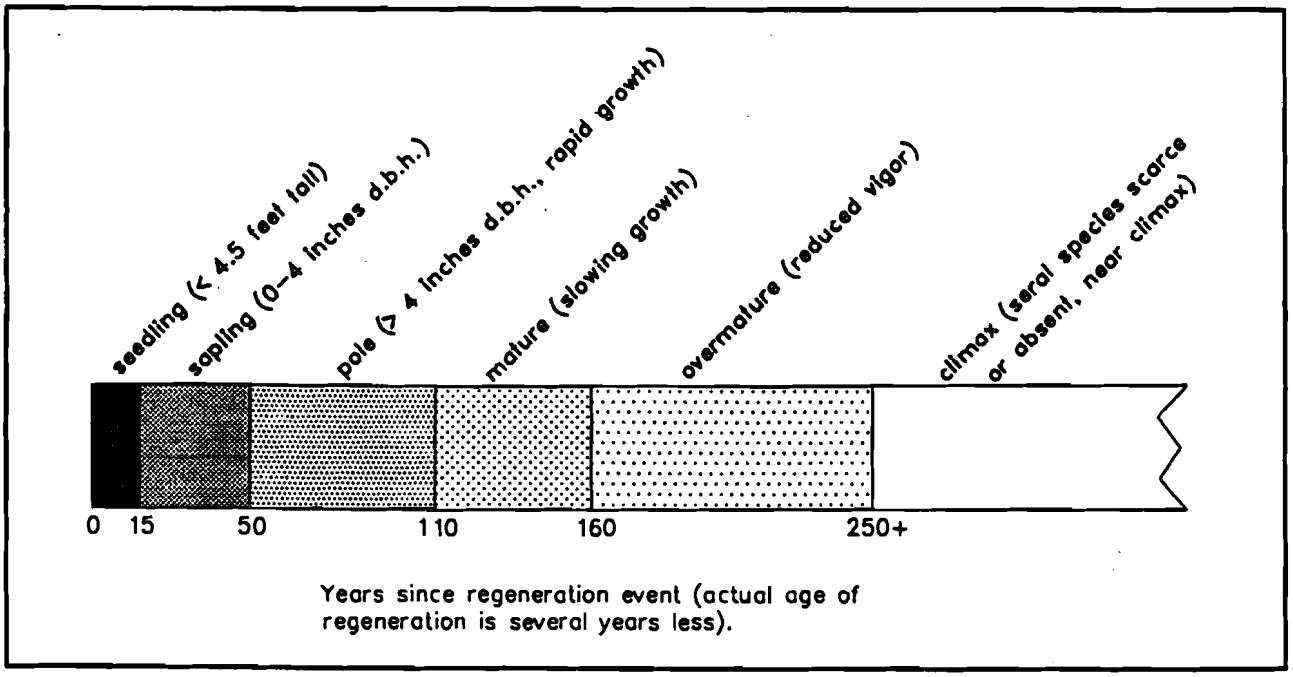

Figure 3—Definitions of structural classes of seral species used in the Lick Creek Headwaters study area.

The species composition at each sample plot should be described for the two time periods. For example, we classified the stands in our study area as either primarily (1) lodgepole pine, (2) whitebark pine, (3) subalpine fir, or (4) mixed, not dominated by a single species. A stand was considered primarily lodgepole pine, for instance, if lodgepole made up more than 50 percent of the stand basal area. Other categories might be useful for other sites. For the historic stands, we estimated stand composition based on a general assessment of current diameter distributions and the growth rates that produced them, along with evidence of dead trees by species.

A stand map can be produced by starting with structural stand types identifiable on aerial photographs. Often in National Forest lands a timber type map based on interpretation of aerial photography is already available. This map can be refined by adding the stand structure and boundary information gathered in the field.

Stand structure and species composition in the two time periods can be compared by summarizing each stand type's percent coverage of the landscape.

PILOT STUDY AREA

To test our methodology we applied it to a 500-acre study area within the 1,500-acre lodgepole pine/subalpine fir forest at the headwaters of Lick Creek, on the Bitterroot National Forest southwest of Hamilton, MT. This study area spans a broad and rather uniform (15 to 30 percent inclination) east-facing slope between elevations of 6,500 and 7,500 feet. Habitat types (Pfister and others 1977) are primarily *Abies lasiocarpa / Xerophyllum tenax* (both *Vaccinium globulare* and *V. scoparium* phases) in the lower elevations, and *Abies lasiocarpa / Luzula hitchcockii*, *V. scoparium* phase at upper elevations. A few sample points fell in the *Abies lasiocarpa-Pinus albicaulis / V. scoparium* habitat type, and one in *Abies lasiocarpa / Menziesia ferruginea*. No timber harvesting has occurred in the study area. In 1988 a portion of the area was burned by the Rock Creek wildfire. This man-caused fire was suppressed, but otherwise probably would have burned through the entire study area, based on the behavior of this fire and others nearby in 1988.

PILOT STUDY RESULTS

The disturbance history at the Lick Creek Headwaters study area is shown in figure 2. The history is synthesized in figure 4 and table 1. Fires burned a substantial portion of the study area in 1720, 1785, 1863, and 1889. The intervals between these major fires ranged from 26 to 78 years, but it has been 102 years since the last major fire in 1889. The interval would have been 99 years if the man-caused fire in 1988 had not been suppressed.

Most fires differed in severity from one sample point to another, giving rise to a complex mosaic of single-aged and multiple-aged stands. Figure 5 illustrates this mosaic in the two time periods. A typical fire history study (Arno and Sneck 1977) would probably not depict fire activity and postfire succession on such a small scale.

In 1900 an estimated 77 percent of the study area was dominated by lodgepole pine (table 2). By 1987, nearly a century after the area's last major disturbance, lodgepole covered just 51 percent. Coverage of lodgepole pine stands evidently will increase to 57 percent of the area after the stands burned in 1988 regenerate. The coverage of stands dominated by subalpine fir almost doubled between 1900 and 1991. In 1900, 14 percent of the stands were dominated by whitebark pine; whitebark pine dominated none of the stands in 1991. Mixed composition stands covered none of the area in 1900, but covered 26 percent in 1991.

Table 3 shows the transitions in species composition in more detail. For example, the first row of the table shows transitions for plots dominated by lodgepole pine in the year 1900. In 1991, 74 percent of these plots continued to be dominated by lodgepole, 22 percent had converted to mixed species, and 4 percent had converted to subalpine fir. All of the plots that were dominated by subalpine fir remained in that category. The first column for lodgepole pine in 1991 indicates the lack of disturbances that could have converted other stands into lodgepole stands. No stands that were previously whitebark pine or subalpine fir were converted to lodgepole pine. The column of zeros for whitebark pine in 1991 shows that stands dominated by this species were no longer found in the study area.

An even more striking indicator of the change from seral to climax species is the decrease in younger components of seral species between 1900 and 1991 (tables 4 and 5). Aside from the sample points burned in the 1988 Rock Creek fire, no stands currently have lodgepole pine seedling or sapling components. In 1900 seedling and sapling stages were well represented. In 1900, 72 percent of the study area had immature age classes of lodgepole pine (seedlings, saplings, and poles); by 1991 just 57 percent did.

Table 6 examines the transitions in stand structure. The relatively large number of zeros below the diagonal line of the table reflects the lack of disturbance over the period.

The extent of stands with significant cone-bearing whitebark pine (defined as trees >6 inches d.b.h.) was also estimated for 1900 and 1991. Whitebark pine's nutlike seeds are important for wildlife. We considered more than 20 percent of stand basal area to indicate a significant level of abundance. Although

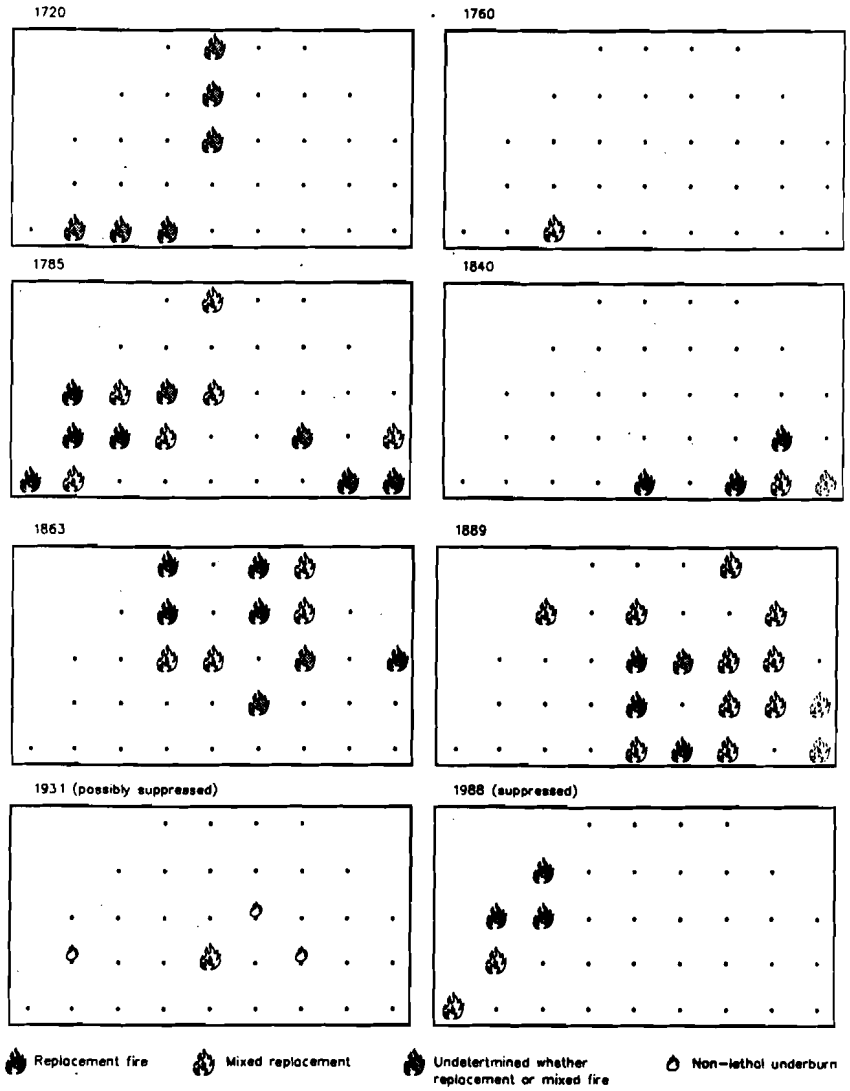

Figure 4—Spatial occurrence and severity of past fires in the Lick Creek Headwaters study area. Each dot corresponds to a sample plot.

Table 1—Extent and severity of past fires in the Lick Creek Headwaters study area. In some cases, replacement fires cannot be distinguished from mixed fires

Fire year	Extent of fire[1]	Fire severity[2]			
		R	M	R/M	N
1720	6/6			100	
1760	1/6		100		
[3]1785	14/17	[4]21	43	36	
1840	5/20	60	40		
1863	11/29	55	36	9	
[3]1889	16/35	25	75		
1931	4/35		25		75
[3]1988	[5]5/35	60	40		

[1]Number of plots on which a fire was detected over the number of plots where fire records extended back that far.

[2]Fire severity classes: R = replacement fire (no survivors, causes regeneration); M = mixed (many survivors, causes regeneration); R/M = undetermined whether replacement or mixed; N = non-lethal (nearly all trees survive, no regeneration).

[3]Major regional fire year.

[4]Percent of burned plots.

[5]The 1988 Rock Creek fire was suppressed within the southern edge of the study area.

Table 2—Stand composition of the study area in 1900 and 1991, based on species basal area. Sample plots were characterized as lodgepole pine if at least 50 percent of the basal area at the sample plot was lodgepole pine, and so on. Values are percent of the sample plots dominated by lodgepole pine, subalpine fir, or whitebark pine, or mixed (not dominated by a single species)

Stand composition	1900	1991
Lodgepole pine	77	57
Subalpine fir	9	17
Whitebark pine	14	0
Mixed species	0	26

Table 3—Transition matrix for species composition changes between 1900 and 1991. Values indicate the percent change from one stand type to another. Stand types are defined as in table 2

	1991			
1900	Lodgepole pine	Whitebark pine	Mixed species	Subalpine fir
Lodgepole pine	74	0	22	4
Whitebark pine	0	0	60	40
Mixed species	—	—	—	—
Subalpine fir	0	0	0	100

Table 4—Percentage of the study area covered by three stand types based on structural age classes of lodgepole pine in 1900 and 1991. Immature stands are limited to stands containing seedlings, saplings or poles; mixed stands contain at least one immature seral age class as well as a mature or overmature component; stands without an immature component have not experienced disturbance within 110 years

Stand type	1900	1991
Immature	49	20
Mixed	23	37
No immature	28	43

it may be possible to confuse individual older dead whitebark pine and lodgepole pine trees, it is possible to determine whether whitebark pine was a major overstory component based on its stoutly branched and forked snags that stand for many decades.

Stands with at least 20 percent basal area of cone-bearing whitebark pine occurred on an estimated 37 percent of the sample plots in 1900. In 1991, whitebark pine was this abundant only on 17 percent of the sample plots. Additionally, the average diameters of overstory whitebark pine were much smaller in 1991 than in 1900. The median diameter of overstory whitebark pine in 1991 was 7 inches. Much of the large-diameter whitebark pine that had been present in 1900 was killed by bark beetles in the 1930's.

Sample data collected on a regular grid lends itself to computation of indices to assess landscape pattern. For example, diversity, dominance and contagion are indices developed from information theory (O'Neill and others 1988; Turner and Ruscher 1988). These three indices were computed for the study area using individual sample points as data, as represented by the grids in figure 5.

Diversity is computed as:

$$-\sum_{k=1}^{m} (P_k) \log (P_k)$$

where P_k is the proportion of the landscape in stand type k, and m is the number of stand types present. Larger values indicate more diversity in the landscape. The largest values result when equal areas are in each stand type.

Table 5—Detailed breakdown of lodgepole pine age class representation in the study area in 1900 and 1991. Values are percentage of the area with a given class. More than one class might be present in any single stand; therefore, totals are greater than 100 percent

Structural age class	1900	1991
Seedlings	43	14
Saplings	29	0
Poles	14	43
Mature	40	49
Overmature	14	40
Lodgepole pine absent	0	6

Table 6—Transition matrix for changes in structure of lodgepole pine between 1900 and 1991. Values indicate the percent change from one stand type to another. Stand structural classes are defined in figure 3

	1991			
1900	Immature	Mixed[1]	Mature	Overmature or absent
Immature	29	29	42	0
Mixed	0	75	25	0
Mature	22	22	0	56
Overmature or absent	0	0	0	100

[1]Mixed stands include both immature and mature age classes.

Dominance is the difference between maximum possible diversity and observed diversity. It is used to indicate the extent to which the landscape is dominated by a stand type. It is computed as:

$$1 - (\text{Diversity}/\log(m))$$

where m is the number of stand types present.

Contagion is computed as:

$$2m \log(m) + \sum_{i=1}^{m} \sum_{j=1}^{m} (Q_{i,j}) \log(Q_{i,j})$$

where $Q_{i,j}$ is the proportion of sample points of stand type i that are adjacent to sample points of stand type j and m is the number of stand types present. Contagion is used as a measure of the extent to which stand types are clumped. Lower values mean that the different stand types are broken up and widely distributed over the landscape, while large values near $2m \log(m)$ mean that stand types are aggregated: a given area, or in this case sample point, is more likely to be near other similar areas than expected if stand types were randomly distributed.

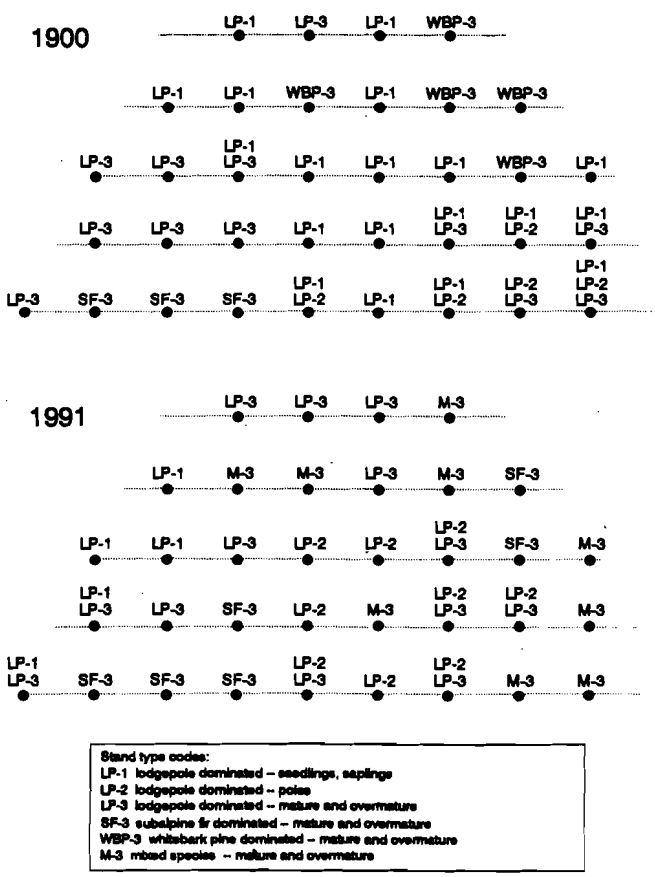

Figure 5—Stand types identified at each sample plot in 1900 and 1991. Mixed species stands (m-3) may include a mixture of lodgepole pine, subalpine fir, whitebark pine, Engelmann spruce, or Douglas-fir. See figure 3 for definitions of structural types.

Table 7—Landscape indices quantifying characteristics of the landscape mosaic in 1900 and 1991, as represented in figure 5

	Diversity	Dominance	Contagion
1900	1.80	0.22	0.85
1991	1.85	.20	.74

Landscape indices for the two time periods are reported in table 7. The sample size was rather small for computing these indices. Ten different stand types are represented in figure 5. Of these, eight were present in 1900, and seven in 1991. If all 10 types were equally represented in a landscape, its index of diversity would be 2.3; if only one type were present, diversity would be 0. The landscapes represented in figure 5 have fairly similar diversity values of 1.80 (1900), and 1.85 (1991). Dominance, which can range from 0 to 1, decreased very slightly over the time period. It was low in both time periods, indicating that the landscape was not dominated by a single stand type. Contagion was also low in both time periods, indicating that the different stand types were not contiguous blocks, but were scattered over the landscape.

These computations were applied to stand type only, and thus address the pattern of the mosaic as a whole, not biodiversity considerations such as overall species richness.

CONCLUSIONS

The data produced and synthesized with these procedures allows detailed comparison of landscape mosaics in the past, the present, and under future management scenarios. Pre-1900 disturbances and the resulting stand structure and composition and landscape mosaic can be compared directly with the current and projected disturbance patterns and the resulting stand attributes. If undesirable conditions and trends are identified, land managers will have quantitative information for better management strategies.

In our pilot study area, for example, pre-1900 fires were relatively frequent but patchy, resulting in a fine-grained mosaic of young and mixed-age lodgepole pine communities with few late-successional stands dominated by fir. Conversely, disturbances have been less frequent and succession has advanced throughout the area since 1900. A manager might use this information and data on forest fuels to consider whether a new pattern of fire frequency and severity is emerging—namely, severe stand-replacing fires occurring at long intervals (Barrett and others 1991). Another trend in this study area is the dramatic

decline in overstory whitebark pine, bad news for wildlife species that depend on it.

We feel that the relatively simple procedures outlined here will provide the kind of information useful for evaluating forest landscape patterns and trends. The findings and their interpretations for land management planning will be unique for each area studied.

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WHEELER CREEK BURN - WHITEBARK PINE REGEN MONITORING STUDY

BACKGROUND: The Wheeler Creek prescribed crown fire was ignited during the fall of 1988 and intensively burned approximately 400 acres within an elevational range of 5000 ft to 7200 ft MSL. One major objective of this successful burn was to promote whitebark pine regeneration for improving grizzly bear food habitat. Approximately 1/4 of the burn was within the elevational limits of whitebark pine. Participants of a previous whitebark pine workshop identified the current lack of methods and money to determine the success of prescribed burns such as the Wheeler Creek burn. With current funding and personnel levels, it is very difficult to determine if a prescribed burn has accomplished the objectives stated in the burn plan. As a consequence, the Intermountain Fire Sciences Lab decided to locate permanent plots in the Wheeler Creek burn to monitor whitebark pine regeneration to evaluate the success of that burn and learn from the process.

METHODS: During the summer of 1994, we established 29, one-hundredth acre circular macroplots on 3 transects in whitebark pine habitat on the Wheeler Creek burn. All transects were established above the 6600 foot elevation contour. Each plot was systematically located along each transect at 300 foot intervals at an azimuth of 270 degrees. Number of trees by species and size class (diameter and height), ground cover and vascular plant cover by species were recorded at each plot. The severity of the burn was also rated for each plot. Photos were taken due west and due south at plots 1-17. All data and methods are on file at the Intermountain Fire Sciences Lab.

RESULTS: There was no whitebark pine regeneration in any of the burned area of the burn. Approximately 10% of plots were in unburned portions of the burn and there were 5 whitebark pine trees (160 trees/acre) and 4 subalpine fir trees (130 trees/acre) total for all unburned plots (3 plots). These trees were between 10 and 50 years old (i.e., survived the burn). No trees were found on burned plots. Most plots had moderate severity burns (38% mod, 28% high, 24% light). Vascular plant cover averaged about 10% across all plots with rock and bare soil comprising the majority of ground cover (30% bare soil cover, 21% rock). This burn had an average aspect of 182 degrees with 78% slopes.

DISCUSSION: The whitebark pine seed sources surrounding the burn are dying from blister rust infection. However, there does seem to be some rust-resistance in the surrounding population. The current lack of whitebark pine regeneration is NOT any indication that the burn has failed to meet its primary objective. Whitebark pine regeneration generally takes quite a while on high elevation sites with establishment lags of 20 to 30 years not uncommon. The southern exposure and steep slopes of Wheeler Creek burn contribute to make this site severe for tree establishment. As vascular cover increases and the soil stabilizes, we expect to see abundant whitebark regeneration. The burn has successfully created suitable conditions for nutcracker caching of whitebark pine seeds by removing tree overstory and exposing mineral soil.

VEGETAL RESPONSE FOLLOWING FIRE IN A WHITEBARK PINE COMMUNITY BOB MARSHALL WILDERNESS, MONTANA

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On June 28, 1985, lightning ignited three small fires on the ridge just west of Charlotte Peak in the Bob Marshall Wilderness, MT (Figure 1). These three fires were managed collectively as the Charlotte Peak Prescribed Fire, and were part of a program to restore fire to the Bob Marshall Ecosystem (Lasko 1987). The Charlotte Peak fire burned nearly 5,400 acres before it was extinguished by heavy rains in late July and early August.

A field study was initiated by Spotted Bear Ranger District personnel in the summer of 1986 for the purpose of measuring the response of vegetation to fire. One plot sampled was located in what was a late seral whitebark pine (*Pinus albicaulis*) community. This plot (#114) was located near the point of ignition, just below the main ridgeline west of Charlotte Peak (Figure 2). Data were collected over an 8 year period.

METHODS

The criteria for placing this plot were that the preburn community was a mature stand dominated by *P. albicaulis* and that it was completely consumed by fire. The plot was permanently marked, and measured annually from 1986 through 1990, and again in 1993. The study site is located at an elevation of 7,320 ft with an easterly aspect on a 40 percent slope. Although postfire determination was difficult, the community resembled an *Abies lasiocarpa/Luzula hitchcookii/Vaccinium scoparium* habitat type. The preburn stand was approximately 195 years old with a mixed *P. albicaulis* and *A. lasiocarpa* overstory.

ECODATA Classification Sampling Methods were used (Keane et al. 1990). Species' frequencies and canopy coverages were measured within 25 microplots on a 0.1-acre macroplot. Ground cover and production by life form was also measured. Tree and shrub densities were measured by age class. Other data were also taken for each species, including canopy coverage by age/size class, distribution, phenology, height, and hedging class.

RESULTS

Although a crown-consuming fire occurred, fire severity was low due to (1) low mineral soil and high litter and duff ground coverages (1 to 5 percent and 85 to 95 percent respectively), and (2) the high number of species that resprouted, including *Xerophyllum tenax*, which has rhizome highly susceptible to severe fires (Stickney 1988). This low fire severity influenced

the types of species that returned. Twenty-nine percent of the species found after the fire resprouted from surviving roots (Table 1). Four percent were residual (on site) colonizers, 54 percent were off site colonizers, and 17 percent were of unknown origin (see Table 2 for survival strategy descriptions). Although only 29 percent of all species found over 8 years were resprouters, these species dominated coverage, frequency and production on the site.

One of the more interesting off site colonizers was *P. albicaulis*. Because *P. albicaulis* has an indehiscent cone, it is probable that seedlings were established from Clark's nutcracker seed caching (Tomback 1978). No conifer seedlings were observed until the third year (1988) (Figure 3). Perhaps cone crop production was poor in 1985 and 1986 but good enough in 1987 to explain the 1988 surge in seedlings. Another possibility is that climatic conditions were not favorable for seed germination and/or seedling establishment in 1985 and 1986. Although a number seedlings germinated in 1988, most died before the plot was resampled in 1989. This phenomenon was observed throughout the Charlotte Peak Burn with all species of conifer seedlings. Perhaps the drought of 1988 was severe enough to cause significant seedling mortality. In addition to *P. albicaulis*, two other conifer species were observed in 1993, *Picea engelmannii* and *A. lasiocarpa*, both in lower densities than *P. albicaulis*.

Two other species of particular significance were *Epilobium angustifolium* and *Carex rossii*. *Epilobium angustifolium*'s seeds are windblown onto a site after fire, and after establishment, the species provides vegetative and litter cover. *Carex rossii* usually does not occur in the preburn stand vegetatively, but does so in the seed bank. These seeds remain in the ground awaiting fire to create the proper germination conditions (Lyon and Stickney 1976).

Canopy cover and vegetative production increased immediately after the fire, but has shown no significant changes over the last 8 years. In this harsh upper montane environment, vegetal growth after fire may take many years before significant increases in both cover and production are noted.

Fourty-six percent of the species present became established or reestablished in year 1 (1986) (Table 1). Although 54 percent of species were established in later years, the species with dominant cover and frequency were the resprouters, such as *X. tenax* and *Menziesia ferruginea*. One exception was *C. rossii*, a residual colonizer which was not noted until year 2 (1987), but covered three percent of the site by 1993.

This unreplicated plot represents but a small portion of the whitebark pine community in the Charlotte Peak Burn, therefore I cannot expected that inferences on vegetal response can be made using these data. However, some observations regarding species establishment after fire, in particular regeneration of whitebark pine, are always worth noting even if only observational in nature.

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I would like to thank Peter Stickney who has spend much of his precious time increasing my understanding of secondary succession.

Table 1. Survival strategies for vascular plant species in plot 114 (years after fire the species was first observed).

Residual Colonizer	Off Site Colonizer	Resprout	Unkown Origin
Carex rossii (2)	Epilobium angustifolium (1) Hieracium albiflorum (1) Senecio triangularis (1) Abies lasiocarpa (3) Pinus albicaulis (3) Tragopogon dubius (3) Epilobium watsonii (3) Xerophyllum tenax (4)* Picea engelmannii (8) Elymus glaucus (8) Trisetum spicatum (8) Hieracium gracile (8) Taraxicum officinale (8)	Menziesia ferruginea (1) Vaccinium globulare (1) Vaccinium scoparium (1) Luzula hitchcocki (1) Arnica latifolia (1) Pedicularis racemosa (1) Xerophyllum tenax (1)	Viola orbiculata (1) Carex geyeri (4) Pyrola secunda (2) Pedicularis contorta (4)

* X.tenax seedlings were observed in 1990 and 1993.

Table 2. Survival strategies for plant species following fire (Lyon and Stickney 1976).

Strategy	Description
off site colonizer	establishment by an off site seed source dispersal mechanism usually wind or animal
residual colonizer	establishment from an on site seed source, either in the ground or in the canopy
resprout (survivor)	establishment from surviving rhizomes, root crowns, or underground tubers, corms or bulbs. This strategy depends on fire severity and susceptibility of roots to heat treatment

ROLES OF USDA FOREST SERVICE GENETIC RESOURCE PROGRAM IN ECOSYSTEM MANAGEMENT IN OREGON AND WASHINGTON

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ABSTRACT-The USDA Forest Service genetic resource program in Region 6 includes a team of geneticists serving Oregon and Washington. The program interacts with internal and external resource specialists to provide guidance on genetics and seed production of tree, grass, forb, and shrub species. The wealth of experience present in the genetic resources program can help reduce costly mistakes in carrying out new programs and would complement that of other resource people seeking input on genetic and seed collection issues. The resident team of geneticists and associated specialists has extensive experience with establishment of field administrative studies, seed collection, seed extraction, and seed storage, and can help plan and implement projects which require this type of information.

Species such as western larch, ponderosa pine, western white pine, and white bark pine are important components of the western interior forests and the genetic resources program has efforts underway to work with these species. Examples of new or ongoing efforts of the genetic resources program include a) screening and breeding for blister rust resistance in white pines, b) examining genetic variation in species of interest (via common garden studies or isozymes)to help delineate seed movement guidelines, c) establishment of seed production areas, seed orchards, or containerized seed orchards to meet urgent demands for seed quickly, d) initiation of a survey of whitebark pine status in Oregon and Washington, e) organization of multi-discipline training courses on blister rust, tree climbing, and seed collection and storage, f) storage of individual plant collections of seed or pollen for further study or short- to mid-term germplasm storage. The experience and facilities available to the genetic resource program makes it possible for the program to respond to urgent needs and to pull in assistance from other resource specialists, researchers, or organizations.

WHITEBARK PINE MYCORRHIZAE: RESULTS OF PRELIMINARY EFFORTS TO ISOLATE FUNGI FROM ROOTS OF FIELD-COLLECTED SEEDLINGS

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ABSTRACT

It would be difficult to find a conifer growing under natural conditions that is not colonized by some type of mycorrhizal fungus. Many field and greenhouse studies have shown that mycorrhizae benefit plants through increased nutrient uptake, drought-stress resistance protection from pathogens. The symbiosis is especially important under nutrient-poor conditions. In nurseries the application of chemical fertilizer tends to reduce or prevent mycorrhizal formation.

We report here results of preliminary efforts to isolate cultures of mycorrhizal fungi from the roots of field-collected whitebark pine and propose steps for continued research. Whitebark pine seedlings with intact root systems were collected near Siyeh Pass in Glacier National Park in September, 1993. Microscopic examination of fine roots showed typical ectomycorrhizal colonization. Root tips were excised, surface-sterilized and incubated on nutrient agar. Cultures showing evidence of bacterial contamination were discarded. Several fungal cultures were obtained and are stored in the culture collection at the USFS Forestry Sciences Laboratory, Corvallis, OR. The best approach for determining whether the cultures may be of practical parameters such as biomass, root/shoot ratios and tissue nutrient concentrations. Further testing would require outplanting colonized seedlings in native habitat. If warranted, practical microbial techniques could be developed to enhance success of future experiments or planting projects.

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