Comparing Historic and Modern Forests on the Bitterroot Front

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Abstract—A study was initiated in 1995 to measure landscape changes in forest structures between 1900 and 1995. A systematic sampling system was used to collect data on three forested faces on the Bitterroot Front. Over 1,200 tree cores were taken on 216 plots between the elevation range of 4,500 to 7,500 feet. Historic forests were reconstructed through quantitative techniques. Changes are presented in three elevation zones: lower (4,500 to 5,800 feet), middle (5,800 to 6,900 feet), and upper (6,900 to 7,500 feet). Dramatic decreases in fire dependent species and increases in fire intolerant species are shown throughout all elevation zones. Ponderosa pine (*Pinus ponderosa*) has been reduced from 52 percent to 26 percent of total basal area in lower elevations. Douglas-fir (*Pseudotsuga menziesii*) increased its relative percentage of total basal area in the lower zone from 19 percent to 55 percent over the past century. Western larch (*Larix occidentalis*) abundance has declined from 26 percent to 11 percent in lower elevations (4,500 to 5,800 feet) and from 24 percent to only 6 percent in middle elevations (5,800 to 6,900 feet). Lodgepole pine (*Pinus contorta*) has increased its relative percentage of landscape basal area 6 percent in middle elevations and 13 percent in upper elevations (6,900 to 7,500 feet). Whitebark pine (*Pinus albicaulis*) decreased from 39 percent to only 11 percent of total stand basal area in the upper elevation zone.

To provide an historical baseline to aid land managers, we conducted a detailed inventory of representative areas on the northern portion of the Bitterroot Front using plots placed on a systematic grid. At each plot, the current forest conditions and the processes linked to the stand's development were examined. At the same plots, evidence of the historical forest conditions (circa 1900) and the natural processes that shaped the historical stand were also collected. Objectives of the study were to assess changes in stand composition and structure between the historic period, when forests were heavily influenced by natural fire regimes, and the current period, when logging and fire suppression may have become important influences shaping forest conditions.

National forest managers are attempting to develop ecosystem-based management (EM) for the mountain slopes rising directly above the west side of the Bitterroot Valley,

which we will refer to as the "Bitterroot Front." The front is a boundary zone between the Bitterroot Valley, which has become a major suburban and rural residential area, and the Selway-Bitterroot Wilderness. How to maintain the diverse values of forest ecosystems along the Bitterroot Front presents a dilemma for land managers on the Bitterroot National Forest. The Bitterroot Front is a highly valued viewshed for about 30,000 valley residents. Immediately west of the front lies the 1.3-million-acre Selway-Bitterroot Wilderness. However, much of the front itself is outside the Wilderness and has been subject to logging, grazing, intensive recreational use, and suppression of all natural fires.

Environmental laws and regulations guide national forest management toward maintaining a semblance of historical ecological processes as a means of perpetuating communities of the native plants and animals. For thousands of years, fire has been a critical process shaping Bitterroot ecosystems, and since 1973 a natural fire program has allowed many lightning fires to burn in the Selway-Bitterroot Wilderness (Brown and others 1994). Starting in 1988, however, fires originating in the Wilderness have periodically threatened private land and homes along the Bitterroot Front, which lies immediately downwind. Although most of the middle and upper elevations on the Bitterroot Front lie within the national forest, much of the lower elevation forest is in private ownership. In the last 25 years hundreds of homes have been built here, many located in hazardous forest fuels. National forest managers are directly or indirectly responsible for protecting forests and homes from severe wildfires.

Methods

This assessment was based on a detailed sample of forest conditions on representative portions of the Bitterroot Front, with large numbers of sample plots measured on systematic grids.

The Bitterroot Front consists largely of broad triangular ridge faces rising above the Bitterroot Valley (fig. 1). The lower slopes begin at elevations of 3,500 to 4,000 feet and are covered with ponderosa pine (*Pinus ponderosa*)-dominated forests. At increasing elevations other species become dominant, with whitebark pine (*Pinus albicaulis*)-dominated forests occurring at the highest elevations, around 8,000 feet (fig. 2). Three ridge faces considered representative of the Bitterroot Front were selected for intensive sampling. On each face a grid of parallel transect lines was laid out, running directly up the slopes (fig. 3). Structure of the current and past forests was sampled on 1/10th acre circular plots located at 500-foot intervals along each transect. See
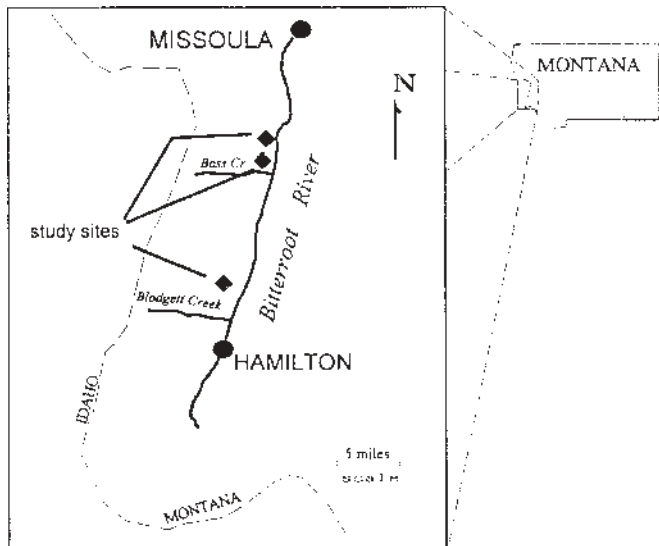
Figure 1—Map of southwestern Montana showing locations of the three study sites (from Hartwell and Alaback 1996).

constraints and difficult accessibility prevented sampling above 7,500 feet.

To record current stand conditions, all live trees were tallied by species and diameter. Major disturbances related to the development of the current stand—logging, thinning, fires, and bark beetle (*Dendroctonus* spp.) epidemics—were recorded. Studies of forest history in this region suggest that forest conditions in about 1900 were generally still representative of the pre-fire suppression, pre-logging period (Arno 1976; Arno and others 1995). To estimate circa 1900 conditions, increment borings were collected from trees of each species and different diameter size classes to allow calculation of the diameter of each tree in 1900 by measuring and subtracting post-1900 growth from the tree's diameter. Additionally, all dead trees (standing and fallen, greater than 6 inches in diameter) that would have been alive in 1900, were recorded by species and diameter (Arno and others 1993, 1995). Decay classes of Maser and others (1979) were assigned to dead trees and these were later used to estimate time since death. The severities of historical fires associated with the circa 1900 stands—low-intensity underburns, mixed-severity fires, or stand-replacing fires (Brown 1995)—were determined based on trees that survived, fire scar sequences on trees and stumps, and fire-initiated age classes of trees (Arno and Sneck 1977; Barrett and Arno 1988).

A total of 216 plots were sampled for both current and historic conditions in the three study areas. Over 1,200 trees were aged from increment cores and the age-diameter relationships were used to develop regression equations to describe the growth rates of each species (Hartwell and Alaback 1997).

Hartwell and Alaback (1997) for a detailed explanation of study methods. Transects were established between 4,500 and 7,500 feet in elevation. Areas below 4,500 feet usually were logged in the late 1800's and had more slash burning and other human activity, such that stumps and evidence of previous forests may have been severely diminished. Time
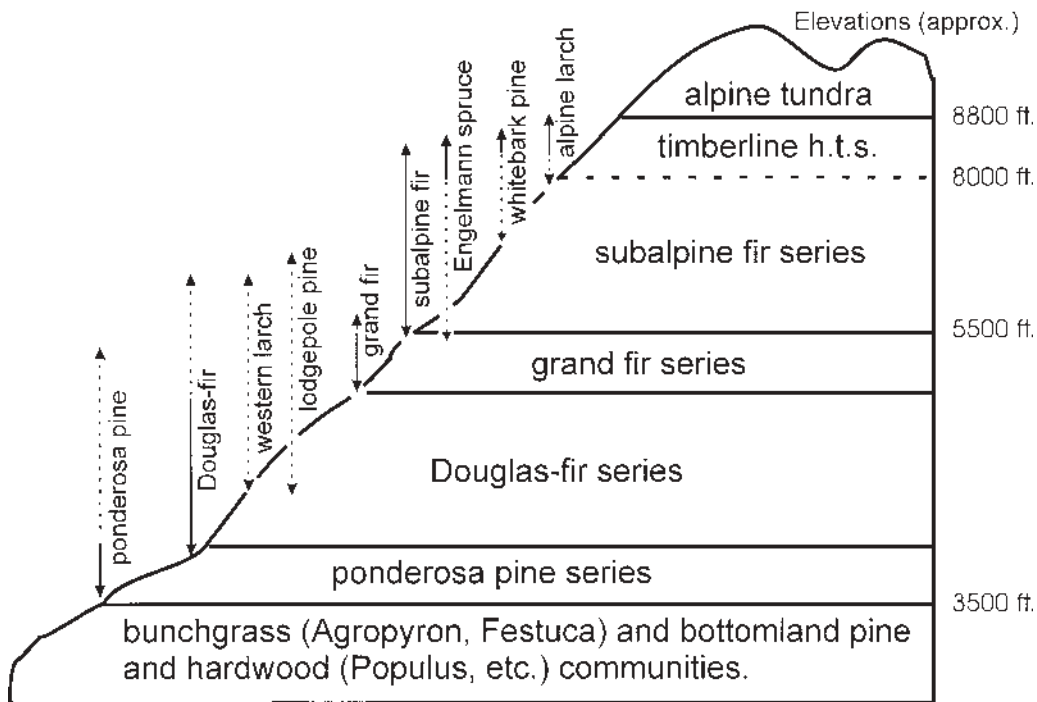

Figure 2—Typical distribution of forest trees on the Bitterroot Front (from Lackschewitz 1986).
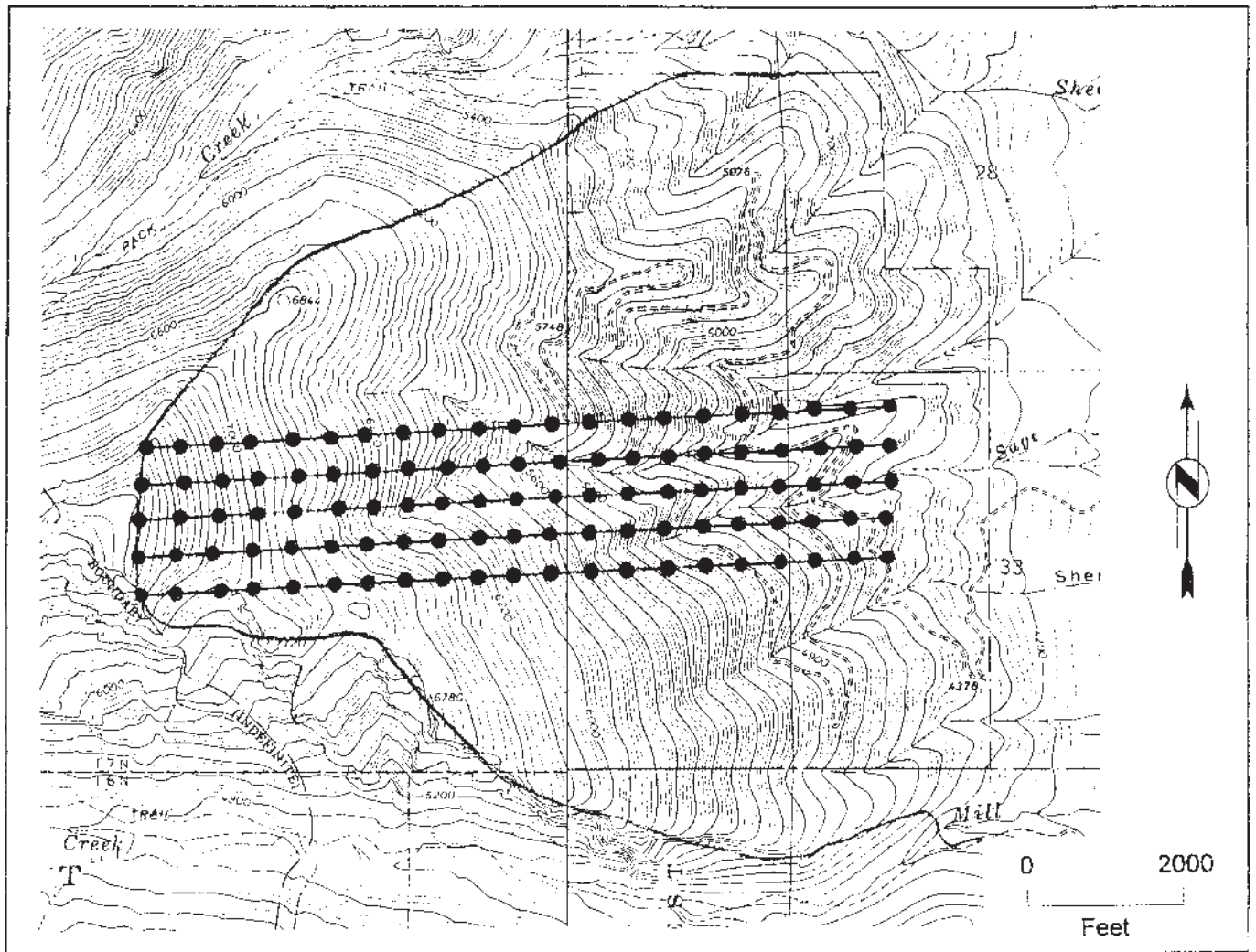
Figure 3—Plot locations on a sampling grid at one of the sutdy sites (from Hartwell and Alaback 1996).

Results and Discussion _____

At this time, we are able to provide a synopsis of the comparison of historical and current forest composition in the lower, middle, and upper elevations. (When the analysis of the study data is completed, we will be able to report additional information about characteristics of the structure and composition of historic forests.) The 216 sample stands were stratified into three elevational zones linked to historical forest composition. The forests sampled below 5,800 feet elevation were historically dominated by ponderosa pine. Forests between 5,800 and 6,900 feet were dominated by mixtures of lodgepole pine (*Pinus contorta*), western larch (*Larix occidentalis*), Douglas-fir (*Pseudotsuga menziesii*), and subalpine fir (*Abies lasiocarpa*). Forests above 6,900 feet were dominated by whitebark pine and lodgepole pine.

Figure 4 compares the relative basal areas of the different tree species in the lower elevation forests in 1900 and 1995. Basal area per acre is the cross-sectional area of all tree stems and serves as a rough index of tree biomass. According

to these data, ponderosa pine was the most abundant tree in 1900, but is now replaced in that status by Douglas-fir. Similarly, western larch was second in abundance in 1900, but has now become a distant third. Logging in the early and mid 1900's removed the majority of large ponderosa pine and larch as well as some of the larger Douglas-fir. Elimination of frequent low-intensity fires, which were characteristic of this zone, allowed Douglas-fir to regenerate in abundance. As small trees, Douglas-fir are more fire sensitive than pine and larch.

Figure 5 compares the relative basal areas of different trees in the middle elevations (5,800 to 6,900 feet). About half of the plots in this zone had experienced logging. The primary fire-dependent tree, lodgepole pine, has maintained its historical abundance. The young lodgepole stands that regenerated after late 1800's fires now contribute more basal area due to growth of these trees. Also, lodgepole pine has regenerated heavily in the clearcuts made during the 1960's, 1970's, and 1980's. Larch, historically a major forest component on cool exposures, is now a relatively minor component. This is probably a result of logging the large

Percent of basal area by species
Low Elevation, 4500 to 5800 feet elevation

PP 52

PP 26

LPP 3

DF 55
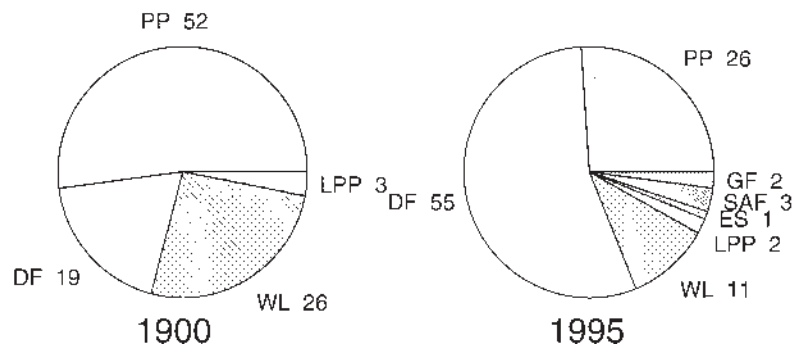
GF 2
SAF 3
ES 1
LPP 2

DF 19

WL 26

WL 11

1900

1995

Figure 4—Relative basal areas per acre by species in the lower elevational plots.

trees—although in clearcuts, larch has often regenerated. In partially cut and uncut stands, larch tends to be replaced successionally by shade-tolerant subalpine fir and Douglas-fir. Subalpine fir, the most fire-sensitive and shade-tolerant tree, has increased substantially, presumably as a result of successful suppression of fires. Circa 1900 stands had arisen after mixed-severity fires (killing some trees and leaving others) and stand-replacement fires.

Figure 6 compares the relative basal areas of different trees in the upper elevation study zone (6,900 to 7,500 feet), where no logging has occurred. Historically, whitebark pine was the most abundant species, but today it is a relatively minor component. Today, whitebark pine is abundant only at still higher elevations, from 7,500 or 8,000 feet to tree line, at about 8,800 feet. In contrast, subalpine fir was histori-cally a minor component, but it has become second only to

lodgepole pine. Lodgepole pine has expanded in basal area due to its growth on late 1800's burns in two of the three study areas. The data on number of trees per acre by species in historical and modern stands show trends similar to those of basal area, with the number of Douglas-fir (at lower elevations) and subalpine fir (at middle and upper eleva-tions) increasing greatly in modern times. (These data will be reported as the study analysis progresses.)

Table 1 compares the circa 1900 and 1995 stand struc-tures at all 216 study plots (4,500 to 7,500 feet elevation) based on which species had the greatest basal area. Overall, the long-lived fire-dependent trees (ponderosa pine, western larch, and whitebark pine) declined dramatically between 1900 and 1995. The old growth trees of these three species have high value as habitat for cavity nesting birds and mammals, and whitebark pine is a source of large, nutritious

Percent of basal area by species
Mid Elevation, 5800 to 6900 feet elevation

WL 24

DF 24

WL 6

DF 24

LPP 27

PP 3
ES 1

PP 1

WBP 5

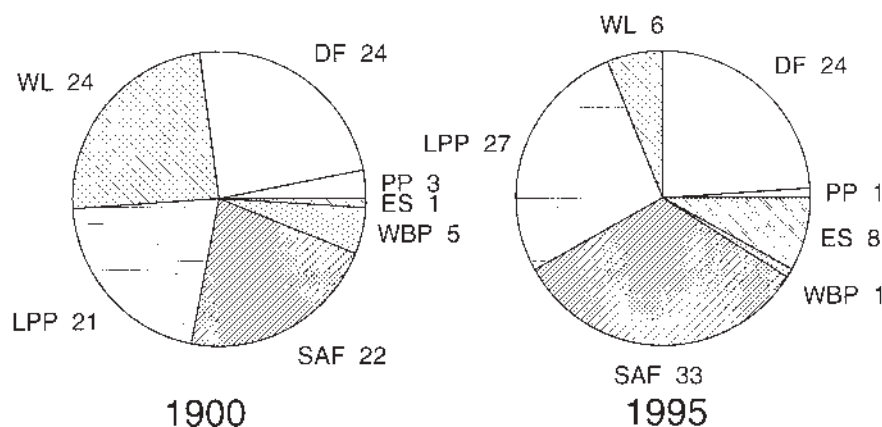ES 8

LPP 21

WBP 1

SAF 22

SAF 33

1900

1995

Figure 5—Relative basal areas per acre by species in the mid-elevational plots.

Percent of basal area by species
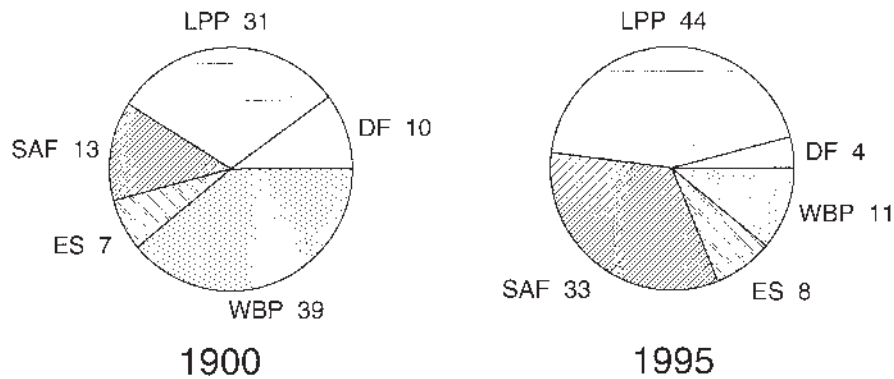### High Elevation, 6900-7500 feet elevation

Figure 6—Relative basal areas per acre by species in the upper elevational plots.

seeds, heavily used by Clark's nutcrackers (*Nucifraga columbiana*), squirrels (*Tamiasciurus hudsonicus*), other small mammals, and bears (*Ursus* spp.). The short-lived, fire-dependent lodgepole pine has maintained its former abundance. Fire-susceptible and relatively shade-tolerant trees (Douglas-fir, subalpine fir, and Engelmann spruce [*Picea englemannii*]) have increased in abundance.

These data indicate that changes commonly reported in individual stands are also happening on a landscape scale. These changes vary with elevation and forest type. Forests historically dominated by large old ponderosa pine and larch have been replaced by dense stands composed primarily of small Douglas-fir and subalpine fir. At higher elevations (6,900 to 7,500 feet), mature whitebark pines are disappearing, presumably due to damage by blister rust and competition from subalpine fir and other species. This is shrinking the whitebark pine zone to only the upper half of its historic range, well above 7,500 feet. The lodgepole pine cover type, in the middle elevations, is maintaining its historic abundance. Where fires occur in these forests, lodgepole pine and associated seral shrubs and herbs will probably regenerate in abundance; conversely, if fire protection continues to be largely successful, there will be a loss of seral shrubs and herbs (Arno and others 1985, 1993; Stickney 1990). The strong increase in subalpine fir at middle and upper elevations suggests that where fire is largely removed, landscapes will shift to dominance by fir.

Conclusion

These data indicate that a shift of forest composition and stand structure has occurred on the Bitterroot Front. In general, dense, fir-dominated stands have largely replaced more open ponderosa pine, larch, and whitebark pine forests at lower and upper elevations. Historically, the forests were dominated by long-lived, fire-dependent trees. The new forests are dominated by shorter-lived species that are growing in a structure more vulnerable to insect and disease epidemics and severe wildfires (Hill 1998; Monnig and Byler 1992; Mutch and others 1993; O'Laughlin and others 1993). Change in the forests on the Bitterroot Front is inevitable; the question is whether national forest managers will be able to restore and maintain some of the natural characteristics and processes that were historically associated with these ecosystems.

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Table 1—Number of plots by dominant cover type, named for the tree species that has a plurality of the basal area per acre.

Year	Species[a]							
	PP	WL	WBP	LPP	DF	ES	SAF	Nonforest
1900	40	30	14	44	49	4	32	3
1995	20	13	1	43	77	6	56	0

[a]PP = ponderosa pine (*Pinus ponderosa*); WL = western larch (*Larix occidentalis*); WBP = whitebark pine (*Pinus albicaulis*); LPP = lodgepole pine (*Pinus contorta*); DF = Douglas-fir (*Pseudotsuga menziesii*); ES = Englemann spruce (*Picea englemannii*); SAF = subalpine fir (*Abies lasiocarpa*).

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