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Using General Land Office Records to Assess Forest Succession in Ponderosa Pine/Douglas-fir Forests in Western Montana

Abstract

Original (1901 and earlier) General Land Office (GLO) records were used to quantify successional changes in Ponderosa Pine/Douglas-fir (*Pinus ponderosa / Pseudotsuga menziesii*) forests in western Montana following altered fire regimes. GLO bearing tree data provided the means to reconstruct presettlement forest structure in the study area: the former Fort Missoula Timber Reserve (FMTR), located in Pattee Canyon near Missoula, Montana. Tree importance values, tree density values and basal area values were estimated from the GLO survey notes and compared to forest data collected in 1992 to assess successional trends. The results show that with reduced fire influence. Douglas-fir in FMTR has made major gains in stand dominance over ponderosa pine and western larch (*Larix occidentalis*), especially on north aspects; on south aspects, former savanna and grassland communities have experienced conifer invasions.

Introduction

Gaining an understanding of long term vegetation history and successional changes linked to human land use practices has become of increasing importance (Habeck 1990, Monnig and Byler 1992, Kaufmann *et al.* 1992). In western North America, for example, wildfire served as an important process in shaping pre-1900 vegetation patterns on Rocky Mountain landscapes. Post-1900 alteration of presettlement fire regimes, as well as logging, domestic grazing, mining, and land cultivation triggered significant changes in the vegetation structure and composition of this region. Some ecologists have linked modern changes in forest structure and composition to potential for severe fires, as well as to reduced forest health (Mutch *et al.* 1993).

In western Montana, Euroamerican settlement intensified and expanded in the 1870's. Prior to 1900 frequent, low intensity fires in the Douglas-fir zone, originating from lightning or from native American ignitions (Arno 1980, Gruell 1985, Barrett and Arno 1982), maintained ponderosa pine-western larch communities as open, park-like forests (Habeck 1990). This specific fire-vegetation relationship in western Montana was evident to early area witnesses (Ayres 1900, Leiberg 1899); circa-1900 photographs taken in western Montana often reveal grasslands and open ponderosa pine woodlands occupying much of the lower half of the area's mountain slopes (Leiberg 1899, Gruell 1983).

With the onset of a national policy of fire exclusion in the early 1900's, along with accelerated logging of old-growth forests, western Montana's montane pine-larch forests have experienced a relatively rapid successional change toward Douglas-fir dominance (Arno *et al.* 1985, Habeck 1985, 1990). Pacific Northwest ecologists have been seeking more detailed, quantitative information on forest changes linked to human activity, including reduced fire (Kaufmann *et al.* 1992, Mutch *et al.* 1993). As resource managers consider how to make historically important processes, such as fire, a part of landscape management, they need to consider various forest structure and composition options. Towards these efforts, they are helped by having historic baseline data points to pre-1900 vegetation structure serving as references; GLO survey records provide such an opportunity (Noss 1985).

General Land Office Survey Records

Relatively detailed, quantitative descriptions of presettlement forest structure and composition can be derived from interpretations of General Land Office (GLO) survey records dating back, in western Montana, to the 1870-1910 era. The GLO notes, which provide data on bearing trees selected to document section corner locations, provide a means to reconstruct presettlement forests (Stearns 1949, Bourdo 1956, White 1976).

In practice, a section corner location was field-marked by a wooden stake or rock monument; the position of this corner was typically described by using four bearing trees, one in each of the four quadrants surrounding the corner. The bearing trees were to be "only the soundest and thriftiest of the trees, and of the size and kind which experience teaches will be the most permanent and lasting" (Stewart 1935). Also, the bearing trees selected were to be within 300 links (198 ft/60 m)

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of the corner being described. Section corners located in savannas or grasslands, often did not have four trees near enough to serve as corner witnesses, and the notes reflected this in specific language, with only 1-3 trees recorded, or none. Tree species, tree diameter, tree distance from the corner, and compass bearing are recorded in the notes. The height at which diameters of bearing trees were to be taken was not specified in the guidelines.

It is necessary for ecologists to practice caution in extracting information from GLO survey notes. Surveyors contracted by GLO followed prescribed instructions in traversing survey lines and describing bearing trees; Stewart (1935) and Dodds (1944) provide details of the operational rules and regulations in effect circa 1900. In a particular locality, such as covered in this report, consideration must be given to the possible existence of individual surveyor bias in applying or interpreting GLO guidelines, or the presence of errors in GLO notes for a specific township or section.

A surveyor might practice differential selectivity in bearing tree selection, partly based on the flexibility built into the guidelines for bearing tree selection, and partially on personal bias. White (1976), working in western Montana (Lubrecht School Forest, University of Montana), detected occasional surveyor bias against small-diameter trees as well as very large diameter trees in GLO notes covering his study area; the exclusion of very small and very large trees as witness trees seems to fit the guideline criteria for bearing tree permanency or longevity. In a preliminary stage of the present study, copies of the original GLO notes were taken into the field (upper Pattee Canyon, Figure 1) and matched with the trees on the modern landscape.

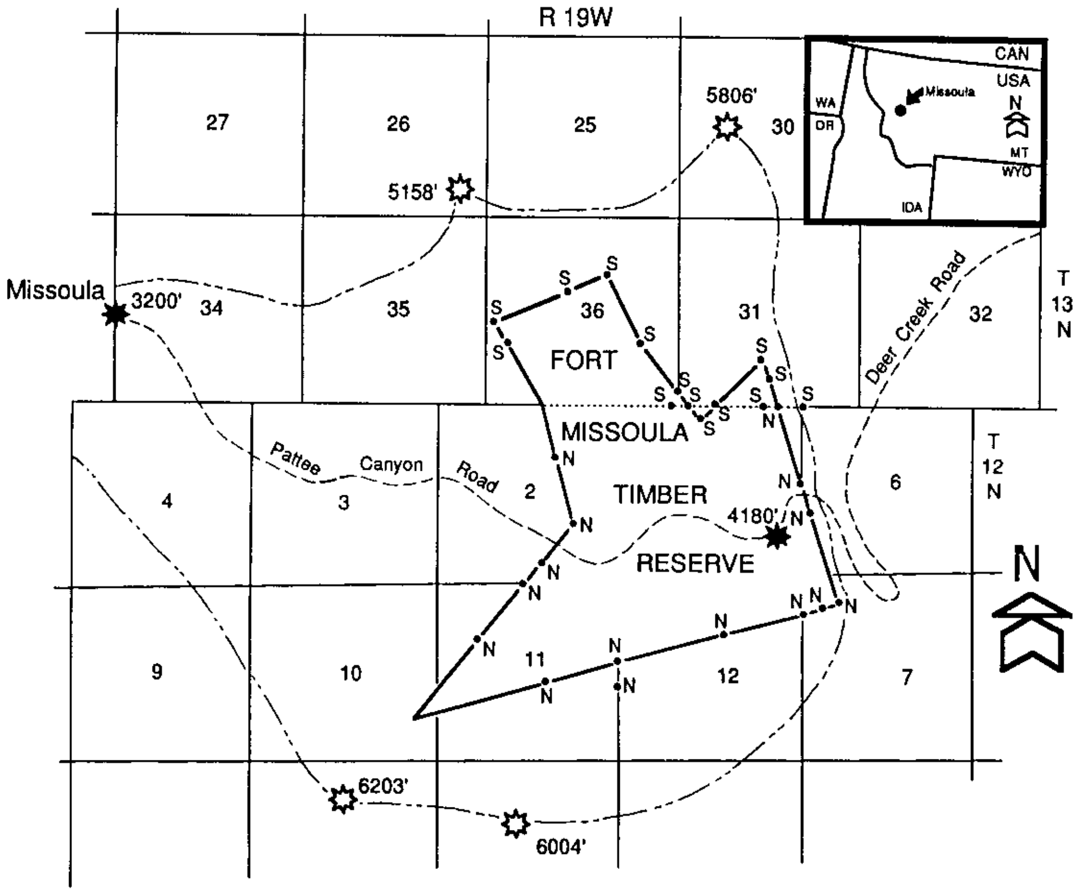

Figure 1. Locations of Pattee Canyon and the former Fort Missoula Timber Reserve (FMTR) in western Montana. The canyon's drainage boundary is shown in dot-dash line, and the canyon's main access road by a dashed line. Surveyed corners and FMTR boundary markers employed in this study are shown by letter symbols, "S" = south aspect sites (n = 14), and "N" for north aspect and ravine sites (n = 15).

Based on the presence and absence of living trees and the remains of earlier existing trees near revisited section corners, it was assessed that bias in surveyor witness tree selection was uncommon.

By revisiting the original section corners, and re-measuring existing trees at each survey corner, it is possible to estimate the direction of forest successional change. Such an effort was undertaken in a military wood and timber reservation, the former Fort Missoula Timber Reserve (FMTR), established in 1879 and located in Pattee Canyon (USDA Forest Service, Lolo National Forest) near Missoula, Montana (Lat. 46° 46′ N, Long. 114° 50′ W, Figure 1); the area is now called the Pattee Canyon Recreation Area (PCRA). Photo copies of the original GLO notes, dated 1901 or earlier, are available for Pattee Canyon and the FMTR in the Missoula County Surveyor's Office, Missoula, Montana.

History of Fort Missoula Timber Reserve

In 1879, a 648 ha (1600 acre) "wood reservation" was set aside by Executive Order in the upper reaches of Pattee Canyon (Figure 1) to fill the fuelwood and construction needs of Fort Missoula, a military facility located 8 km (5 miles) west of Pattee Canyon (USDA Forest Service 1991). The star-shaped boundary of FMTR (Figure 1) appears to have been laid out to encompass a specific concentration of large, (75-150 cm/ 30-60" in diameter) ponderosa pines and western larches occurring in upper Pattee Canyon.

Selection of Fort Missoula Timber Reserve

Fort Missoula Timber Reserve was selected to study historic forest changes for the following reasons: (a) the variety of forest and bunchgrass communities it supports is representative of the lower montane zone forest-grassland types commonly found elsewhere in western Montana; (b) the FMTR's irregular boundary, and its numerous intersections with township and section lines, provides an unusually high concentration of GLO survey corners ("sample points"), and thus an abundance of bearing tree data from relatively homogeneous landscape units; and (c) the relatively light logging disturbance in those portions of Pattee Canyon and FMTR where modern data needed to be taken. When FMTR's surveyed corners were revisited in 1992, only those that appeared to have been the least altered by post-settlement disturbances (other than fire control) were included in the analysis.

Methods

Procedures used to extract phytosociologic information from GLO survey notes are well-documented (Cottam 1949, Bourdo 1956, Habeck 1961, Noss 1985, and Galatowitsch 1990). The General Land Office began contracting surveyors to subdivide public lands in western Montana in 1867, following field techniques standardized in the GLO's 1855 Manual of Instructions (Dodds 1944). GLO surveying parties created sets of field notes for the townships subdivided. Section corner locations were described using bearing trees. At the end of each surveyed mile, and after a township was subdivided, descriptions were provided that mention dominant tree species present, quality of timber, and assessment of agricultural potential. Sometimes the notes included information on general topography, soil quality and timber.

As section lines were being run, the surveyors made note of the line entering or leaving forest cover; the latter, in turn, might be further described as "heavily timbered," "heavy open timber" or "scattering timber." Based on my 1992 re-examination, the term "heavy," as used in the survey notes, is believed to been used to characterize the presence of scattered "large-sized" trees, not necessarily "densely stocked" forests. Ascents and descents of slopes, intersections of gulches, ridges, roads, or fence lines were recorded, as were diameters and species of trees found directly on the line.

Bearing trees in quadrants surrounding the corners were chosen and described in the GLO notes. Typically, four bearing trees (the nearest one in each quadrant) were described at section corners (mile marks), while two trees were recorded at quarter-section (half mile) corners. An excerpt taken from the September 18, 1901 survey notes for the Third Mile along FMTR's boundary on Pattee Canyon's north aspect is as follows:

Chains
40.00 Set a sand stone 22 x 12 x 7 ins.,
16 ins. in the ground, for 2 1/2 Mile cor.
marked 2 1/2 M. on E.
T. R. on N. and
P. L. on S. faces; from which

A pine, 24 ins. in diam., bears N. 10° E., 38 lks.
dist.; marked Ft. M. T. R., 2 1/2 M., B. T.

A fir, 12 ins. diam., bears S. 60° E., 141 lks. dist., marked T. 12 N., R. 19 W., S. 12; 2 1/2 M., B. T.

A fir, 15 ins. diam., bears S. 45° W., 114 lks. dist., marked T. 12 N., R 19 W., S. 12; 2 1/2 M., B. T.

A tamarack, 8 ins. in diam., bears N. 43° W., 67 lks. dist., marked Ft. M. T. R., 2 1/2 M., B. T.

The "40.00" represents a half-mile corner. The "pine" referred to is ponderosa pine, the "fir" is Douglas-fir, and the "tamarack" is western larch. The initials "lks" refers to links, one link equals 7.92". On FMTR's 1901 boundary re-survey, corners, mile marks and half-mile marks usually were described using four bearing trees. Also, wherever the FMTR boundary intersected township and section lines, the points were also described using four bearing trees, if available within the 300 link limit.

At the end of the surveyed "Third Mile", at 80.00 chains, the survey party chief provided the following summary, with the listing of trees in order of dominance, the most dominant listed first:

Land, broken N. slope of mountain.
Soil, sandy., 2nd rate.
Timber, pine, fir and tamarack.
Mountainous and heavily timbered land and through dense undergrowth 80.00 chns."

Bearing tree data resembles plot-less, point-centered distance measurement data (Cottam and Curtis 1956). GLO tree data, when summarized for a series of corners occurring on similar (relatively homogeneous) landscapes, allow calculation of importance values for each tree species defined as the sum of relative density, relative frequency and relative basal area. The distance measures also allow estimates to be made of tree densities (number per hectare) and basal areas (square meters per hectare) for all tree species recorded in the survey notes. Since a majority of the 1901 survey points were witnessed by four bearing trees, the average point-to-tree distances are directly relatable to tree mean area (MA), the value needed to calculate tree densities. In addition, it was assumed in using the 1901 GLO notes that sapling-sized trees, under 10 cm/4" in diameter at groundline, were not selected as bearing trees; no evidence was found in 1992 that trees over 10 cm/4", if alive, had been rejected as bearing trees. The 1901 notes provide data for 30 corner points and 82 bearing trees.

During 1992, the FMTR corners were revisited; one of the original corners could not be relocated (thus n = 29 for 1992). The presence and survivorship of the 1901 bearing trees at each corner point were noted. The diameters of surviving bearing trees were measured at 0.3 m (1 ft) above groundline, or "stump height." Random increment corings of surviving bearing trees at breast height (modern standard DBH, 1.4 m above the ground) and at 0.3 m (1 ft) confirm that diameters recorded in the 1901 notes do represent bearing tree diameters near their bases. White's study (1976) closely supports this finding. A larger sample of 324 presettlement bearing trees covering much of Pattee Canyon indicates that corner-to-bearing tree distances and compass bearings were precisely instrument-measured; bearing tree diameters were regularly recorded, but not exclusively, in even numbers such as: 10", 20", 30", or in multiples of a half-foot: 6", 12", 18", 24", suggesting surveyors simply estimated bearing tree diameters.

The 1992 data were taken at each corner revisited, employing the point-centered quadrant method (Cottam and Curtis 1956). The area around each corner point was divided into quarters using cardinal compass bearings, replicating the same set of quadrants used in 1901. The nearest tree in each quadrant over 10 cm (4") was recorded by species, diameter (30 cm (1 ft) above groundline) and distance (corner-to-tree). In addition, the nearest tree sapling (diameter 2.5-10 cm (1-4"), and nearest tree seedling (under 2.5 cm (1") diameter), but over 1 m (3 ft) high in each quadrant were tallied.

The 1992 data were used to calculate importance values (I.V.) for trees, saplings and seedlings for each species, as well as density and basal area per hectare for each tree species (Cottam and Curtis 1956). Within a 0.04 ha (0.1 acre) circular macroplot around each corner, estimated canopy coverage percentages (Daubenmire 1959) were assigned to each tree, shrub, and herbaceous species present. These latter data were employed in habitat typing (Pfister *et al.* 1977) each surveyed corner location.

To understand how presettlement forest vegetation in FMTR has changed over the past 90+ years, the survey corners were partitioned into two canyon subunits (Figure 1), each encompassing a set of survey corners occupying homogeneous canyon aspects. The FMTR corners occur on

TABLE 1. Post-settlement (1901-1992) forest change* on south aspects in Fort Missoula Timber Reserve, western Montana (Figure 1), based on GLO survey records.

Tree Species	Points Occur.	Number Trees	Basal Area	F %	Den %	Dom %	I.V. %	Density No./Ha	Basal Area/ m^2/Ha
A. 1901 South Aspect Forest Composition:									
PIPO	12**	34	8.5	100	100	100	300	32.8	8.2
PSME	0	0	0.0	0	0	0	0	0.0	0.0
Totals	12	34	8.5	100	100	100	300	32.8	8.2
B. 1992 South Aspect Forest Composition:									
PIPO	14	53	7.5	88	95	99	282	125.2	17.7
PSME	2	3	0.1	12	5	1	18	7.2	0.2
Totals	16	56	7.6	100	100	100	300	132.4	17.9

* = Importance Values (I.V.) = summation of relative frequency (= F %), relative density (= Den %) and relative dominance (= Dom %) values. Density = trees per hectare, Basal Area = square meters per hectare. PIPO = *Pinus ponderosa*, PSME = *Pseudotsuga menziesii*.

** = In 1901, two surveyed corners in grasslands lacked nearby bearing trees. At other corners located in savannas, only 1-3 witness trees were recorded rather than the typical four. In 1992 four trees were recorded at each corner point.

TABLE 2. Summary of 1992 south aspect tree reproduction data* taken at original 1901 GLO survey corners in Fort Missoula Timber Reserve, western Montana.

Species	Points Occur.	Number	F %	Den %	I.V. %	Density No./Ha
A. South Aspect Tree Saplings:						
PIPO	12	35	57	63	120	66.4
PSME	9	21	43	37	80	40.0
Totals	21	56	100	100	200	106.4
B. South Aspect Tree Seedlings:						
PIPO	10	28	53	50	103	73.6
PSME	9	28	47	50	97	73.6
Totals	19	56	100	100	200	147.2

* = Importance Values (I.V.) = summation of relative frequency (= F %) and relative density (= Den %) values. Density = number of saplings or seedlings per hectare.

well-defined southern aspects, northern aspects, and several moist ravines; the latter two site categories were grouped for analysis.

Results

Corners occupying southern aspects fit conifer/grassland habitat types, including: ponderosa pine/bluebunch wheatgrass h.t. (*Pinus ponderosa/Agropyron spicatum* h.t.), ponderosa pine/Idaho fescue h.t. (*P. ponderosa/Festuca idahoensis* h.t). Douglas-fir/snowberry h.t. (*Pseudotsuga menziesii/Symphoricarpos albus* h.t.), and Douglas-fir/rough fescue h.t. (*P. menziesii/Festuca scabrella* h.t.). Stand data for south aspect survey corners are presented in Tables 1 and 2.

Survey corners on northern aspects are classified as Douglas-fir/ninebark h.t. (*Pseudotsuga menziesii/Physocarpus malvaceus* h.t.), with most fitting

TABLE 3. Post-settlement (1901-1992) forest change* on northern aspects of the Fort Missoula Timber Reserve, western Montana (Figure 1).

Tree Species	Points Occur.	Number Trees	Basal Area	F %	Den %	Dom %	I.V. %	Density No./Ha	Basal Area/ m^2/Ha
A. 1901 North Aspect Forest Composition:									
PIPO	14	25	5.2	47	52	72	171	24.7	5.1
PSME	9	11	0.7	30	23	9	62	10.8	0.7
LAOC	7	12	1.3	23	25	19	67	11.8	1.3
Totals	30	48	7.2	100	100	100	300	47.3	7.1
B. 1992 North Aspect Forest Composition:									
PIPO	6	7	1.1	21	12	19	52	40.5	6.5
PSME	14	36	2.8	50	60	45	155	202.5	15.4
LAOC	8	17	2.1	29	28	36	93	94.3	11.9
Totals	28	60	6.0	100	100	100	300	337.3	33.8

* = Importance Values (I.V.) = summation of relative frequency (= F %), relative density (= Den %) and relative dominance (= Dom %). Density = number of trees per hectare. Basal Area = values expressed in square meters per hectare. PIPO = *Pinus ponderosa*, PSME = *Pseudotsuga menziesii*, LAOC = *Larix occidentalis*.

TABLE 4. Summary of 1992 north aspect tree data* sampled at GLO survey corners in Fortr Missoula Timber Reserve, western Montana.

Species	Points Occur.	Number	F %	Den %	I.V. %	Density No./Ha
A. North Aspect Tree Saplings:						
PIPO	6	13	23	20	43	30.1
PSME	12	27	48	50	98	74.8
LAOC	8	16	29	30	59	44.9
Totals	26	56	100	100	200	149.8
B. North Aspect Tree Seedlings:						
PIPO	4	7	20	13	33	24.2
PSME	14	46	70	82	152	153.6
LAOC	2	3	10	5	15	9.4
Totals	20	56	100	100	200	187.2

* = Importance Values (I.V.) = summation of relative frequency (= F %) and relative density (= Den %) values. Density = number of saplings or seedlings per hectare.

within the *Physocarpus malvaceus* phase. The latter phase includes cool, moist sites capable of supporting western larch. North aspect survey corners date are summarized in Tables 3 and 4.

South Aspects

Ponderosa pine was and continues to be the major overstory dominant on southern aspects. In 1901 (Table 1, Part A), the south aspect GLO corner notes recorded ponderosa pines exclusively as bearing trees. The lower density of trees suitable as bearing trees on south aspects led, at times, to the surveyors recording only two or three bearing trees at corners where four trees would have been selected. In fact, two bunchgrass-dominated corner sites lacked, in 1901, bearing trees within the recommended 300 link distance, so none were recorded at these corners. The calculated 1901 south aspect tree density is 32.8 trees per ha (13.3/acre), suggesting an open-canopied pine savanna prevailed; basal area averaged 8.2 m^2/ha (36 ft^2/acre). The 1901 ponderosa pine bearing trees averaged .25 m^2 (2.8 ft^2) in basal area, and an average of 57 cm (22.8") in stump diameter.

At the south aspect points revisited (Table 1, Part B), the magnitude of forest change was very evident. Ponderosa pine still maintained its overstory dominance, but there has been a four-fold increase in tree density reaching 132.4 trees per ha (53.6/acre). In 1992 there was a greater density of pines, but those recorded averaged smaller diameters than those present in 1901, with basal areas averaging 0.14 m^2 (1.5 ft^2), and diameters averaging 42 cm (16.8"). In 1992, three Douglas-firs were tallied at south aspect corners, indicating post-1900 entry of firs on warm, dry FMTR sites, perhaps capable of supporting forests classified within the Douglas-fir climax series (Pfister *et al.* 1977).

Sixteen (47%) of the original 34 south aspect bearing trees were alive in 1992, but these were not always recorded as the nearest tree(s) to the corners during the 1992 re-measurement. Bearing tree mortality appeared mostly due to natural causes (standing snags, wind-thrown logs, broken stumps), but a few of the original bearing trees, positioned on private property outside the FMTR boundary, appear to have been lost to logging, not withstanding the illegality of cutting and removal of section corner bearing trees. The basal areas of the 16 surviving ponderosa pines increased four fold, from an average of 0.11 m^2 (1.2 ft^2), and 37.5 cm (15") in stump diameter in 1901, to 0.44 m^2 (4.8 ft^2), and 75 cm (30") in stump diameter in 1992.

A summary of 1992 structure and composition of the sapling and seedling layers on south slope corners is given in Table 2. Comparable tree reproduction data are not available for 1901. Modern importance values (I.V.) for tree saplings show that Douglas-fir reproduction is currently well represented. Ponderosa pine saplings, originating over the past 3-4 decades, still outnumbered Douglas-fir saplings in 1992. Field observations indicate pine and Douglas-fir reproduction has been invading the open gaps between the old-growth ponderosa pines (Figure 2). The 1992 data show Douglas-fir seedlings equalling established ponderosa pine seedlings in density. Savanna-bunchgrass components are becoming reduced in total area without the frequent fire interventions on southern aspects. Succession towards the potential climatic climax stage dominated or codominated by Douglas-fir and/or ponderosa pine has progressed over the past ninety years (Pfister *et al.* 1977).

Figure 2. Entry of *Pseudotsuga menziesii* reproduction into an old-growth *Pinus ponderosa* community earlier maintained as a savanna by low intensity fires. Photo taken near eastern boundary of Fort Missoula Timber Reserve (Figure 1). Photo by J.R. Habeck, 1990.

North Aspects

The section corners occupying northern aspects and moist ravine sites in FMTR have western larch along with ponderosa pine and Douglas-fir as major forest components (Table 3); both western larch and ponderosa pine are fire-dependent and were favored by the frequent, low intensity burns occurring before 1900 (Habeck, 1990). Although western larch was present, the most common witness tree recorded at north aspect corners in 1901 was still ponderosa pine which displayed the highest importance value, the highest density and greatest basal area values (Table 3, Part A).

The 1992 data from north aspect and ravine corners (Table 3, Part B) show distinct shifts in

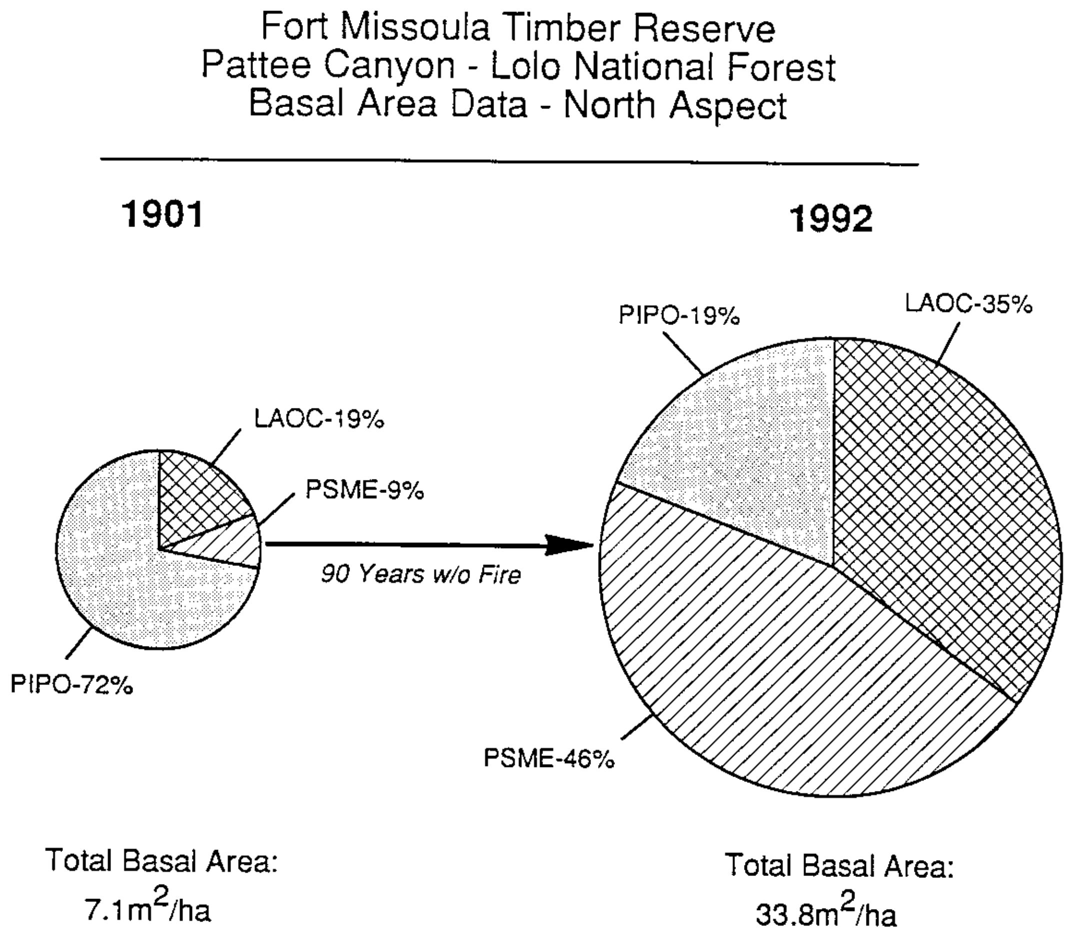

Figure 3. Ninety years of forest change in basal area (m^2/ha) on north aspects in Fort Missoula Timber Reserve, western Montana. Percentages of total basal area per hectare are given for PIPO = *Pinus ponderosa*, PSME = *Pseudotsuga menziesii*, and LAOC = *Larix occidentalis*.

forest structure and composition towards Douglas-fir. Figure 3 emphasizes the significant increase in basal area per hectare, and the much greater importance of Douglas-fir on the modern FMTR landscape. All three conifer species have increased in density and basal area, changing the physical structure of forest cover from open to closed canopy; ponderosa pine has shifted, proportionately, to third place ranking within the modern FMTR forest. About 50% of the original 48 north aspect bearing trees survived to 1992, but these survivors, though larger in 1992 than in 1901, were scattered amongst thousands of smaller Douglas-firs established during the post-1900 era.

A summary of 1992 conifer reproduction data taken from FMTR's northern aspects is provided in Table 4. Although all three species remain present in the lower forest stratum, Douglas-fir dominates the seedling and sapling layers, as might be expected of the potential climax species in the prolonged absence of fire. Ponderosa pine and western larch, although long-lived, benefit by site disturbances (mineral seed bed exposure) in their establishment. Eighty-two percent of all tree seedlings recorded during the 1992 sampling were Douglas-fir. As mature, old-growth ponderosa pine and western larch are lost through natural attrition, with limited replacement, the shift towards overstory dominance by Douglas-fir is predictable (Arno 1980, Habeck 1990).

Discussion

The successful use of GLO survey notes in the Fort Missoula Timber Reserve in assessing direction and magnitude of post-settlement forest change is partly due to the uncommon concentration of surveyed corners in upper Pattee Canyon. The inclusion and description of bearing trees wherever the FMTR boundary intersected township and section lines expanded the quantitative database used to calculate circa-1900 forest structure and composition. Furthermore, the GLO survey note data for upper Pattee Canyon originate from relatively uniform south aspect and north aspect landscape units, allowing the grouping and averaging of the 1901 data. Elsewhere in mountainous parts of the Pacific Northwest, there may be difficulty in assembling a sufficient number of bearing trees to represent homogeneous landscapes supporting similar vegetation or closely related habitat types, as exist in Pattee Canyon. However, where similar analyses of GLO notes are undertaken, in areas lacking the spatial concentration of surveyed corners found in Pattee Canyon, it would be necessary to group bearing tree data taken from similar aspects and elevations within contiguous townships that share biophysical similarities.

Frequent presettlement fires in Pattee Canyon and elsewhere in western Montana are known to have generated and perpetuated pine-larch savanna and grassland types, forming a fire-mediated mosaic. Reduction of fire after 1900 has led to the transformation of the parkland mosaic of ponderosa pine and western larch to closed-canopied, Douglas-fir forest. Resource planning that includes efforts to reconstruct or mimic presettlement pine-larch conditions, such as has been planned for Pattee Canyon (USDA Forest Service 1989), will benefit from efforts to quantitatively document succession and other vegetation changes. Evaluation of GLO survey notes represents a suitable method of assessing historic vegetation change, providing reference points for vegetation management.

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