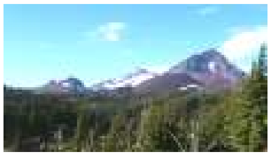

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Stand Reconstruction and 200 Years of Forest Development on Selected Sites in the Upper South Umpqua Watershed

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Prepared for the ***South Umpqua Headwaters Precontact Reference Conditions Study***, November 2010.

Abstract

Stand development of ten structurally complex forest stands in the Upper South Umpqua Watershed was studied by backdating (reconstructing) stand conditions circa 1825. Mixed conifer and conifer/hardwood stands across a selected range of "Areas of Special Interest" sites were sampled for tree ages, tree characteristics, and fire history. Logistic regression analysis was used to create age/diameter models and the stands were backdated using increment core data and tree positions to create stand statistics for 185 years prior to measurement. The changes in number of trees and basal area over the last 185 years were calculated by species for each stand. Density of trees greater than 8 inches DBH increased from an average of 20 trees per acre to 90 (from 10 to 35 trees per acre to 60 to 115 trees per acre). Basal area increased 5-fold on average, from 65 square feet per acre to 225 (from 25 to 150 sqft/ac to 150 to 300 sqft/ac). In 1825 the ten stands were open and park-like with widely spaced trees. By 2010 the ten stands had accumulated from 10 to 20 times the tree biomass they had held 185 years earlier. In 1825 pines and oaks were dominant in stands below 3,800 feet in elevation. Today those same stands are dominated by Douglas-fir, grand fir, and incense-cedar, especially in younger age classes. In higher elevation stands the most abundant species has changed from Shasta red fir to Pacific silver fir.

Several lines of evidence suggest that the prairies, savannas, and open forests have been persistent vegetation types in the Upper South Umpqua Watershed for the last few thousand years, at least. Precontact forest development pathways were mediated by frequent, purposeful, anthropogenic fires deliberately set by skilled practitioners, informed by long cultural experience and traditional ecological knowledge in order to achieve specific land management objectives. At a landscape scale the result was maintenance of an (ancient) anthropogenic mosaic of agro-ecological patches. In the absence, over the last 150 years, of purposeful anthropogenic fires, the anthropogenic mosaic has been invaded and obscured by (principally) Douglas-fir. As a result, the Upper South Umpqua Watershed is now at risk from a-historical, catastrophic stand-replacing fires.

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Introduction

The purpose of this study is to estimate and describe the precontact (~1825) forest conditions and forest dynamics within the Upper South Umpqua Watershed. This study is part of a larger research effort entitled the ***South Umpqua Headwaters Precontact Reference Conditions Study***.

The study area is in the Oregon Cascade Mountains and extends from the Cascade Crest at ~5,500 feet west to the confluence of Jackson Creek with the South Umpqua River at ~1,200 feet. The study area is 231,931 acres or 362.4 square miles in size and is in the Western Cascades bioregion.

The overall goal of the project is to build a body of evidence and analysis that will inform Community Wildfire Protection Plans. That includes increased understanding of historical forest conditions (species composition, structure, density, and age) and the forest dynamics and influences including fire history (frequencies, seasonality, intensity, fuels, spread, and ignition sources and location).

Many southwest Oregon forests are composed of complex, multi-aged mixtures of conifers and hardwoods (Morris 1934, Dickman 1978, Bailey and Kertis 2002, Sensenig 2003, Lake 2005, Carloni 2005, Skinner *et al.* 2006, Tappeiner *et al.* 2007, Zybach 2007, Dubrasich and Brenner 2008, Williams 2010, Dubrasich 2010, and others). Such stands are susceptible to catastrophic fires that endanger communities as well as degrade and destroy natural resources.

In the past, fire was a major factor influencing the structure and composition of these forests. Precontact fires in southwest Oregon forests may have sometimes been stand-replacing, but most fires prior to the 20th century did not eliminate all live trees. Prior to the 19th Century, Native American indigenous residents set fires every 1 to 3 years in Oregon interior valleys (Johannessen *et al.* 1971, Robbins and Wolf 1993, Bonnicksen 2002, Stewart 2002). These frequent fires helped to maintain prairies and savannas in the lowlands, and gave rise to upslope woodlands and forests that were relatively resistant to stand replacement disturbances (Douglas 1914, Morris 1934, Habeck 1961, Dickman 1978, Bonnicksen 2000, Bailey and Kertis 2002, Zybach 2003, Carloni 2005, Lake 2005, Dubrasich and Brenner 2008, Dubrasich 2010 and others).

Comparing past conditions with modern and probable future conditions, and increased understanding of the historical forest development pathways, will help to inform modern management in the pursuit of goals such as forest restoration, reducing catastrophic fire risk, increasing landscape resiliency to fire, insect, and other broad-scale pathogens, protecting old-growth and other heritage resources, and sustaining myriad other natural resource and community values.

The method employed by this study is *back-dated stand reconstruction*, growing the forest backwards in time (Habeck 1961, Johannessen et al. 1971, Arno and Sneck 1977, Morrow 1985, Harcombe 1986, Pitcher 1987, Keter 1995, Keter and Busam 1997, Stewart 1986, and others). This method, a form of retrospective monitoring (assessing historical time series data), begins with development of current stand tables through field inventory. Then stand-based growth models (derived from tree ring evidence) are used to deduce the stand characteristics at some point in the past. Other evidence, either collected and recorded in the field or from historical documentation, is used to refine and validate the estimated historical conditions.

Methods

We selected ten structurally complex multicohort stands (Table 1). All ten stands were deemed "Areas of Special Interest" because of known historical use, and were investigated as part of the larger study of precontact conditions in the Upper South Umpqua Watershed (***South Umpqua Headwaters Precontact Reference Conditions Study***). The stands were also chosen to represent a range of plant community types, from low elevation ponderosa pine/Oregon white oak to upper elevation subalpine mixed conifer. All ten stands had at least two distinct age cohorts of trees.

Found in one or more of the ten stands were a variety of conifer and hardwood species including Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), sugar pine (*Pinus lambertiana* Dougl.), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws), grand fir (*Abies grandis* Dougl. ex D. Don Lindl.), Shasta red fir (*Abies magnifica* Andr. Murray var. *shastensis* Lemmon), Pacific silver fir (*Abies amabilis* Dougl. Forbes), incense-cedar (*I,ibocedrus decurrens* Torr.), mountain hemlock (*Tsuga mertensiana* Bong. Carr.), western red cedar (*Thuja plicata* Donn.), western yew (*Taxus brevifolia* Nutt.), Pacific madrone (*Arbutus menziesii* Pursh), Oregon white oak (*Quercus garryana* Dougl.), and big-leaf maple (*Acer macrophyllum* Pursh.) (Hitchcock and Cronquist 1973).

Although portions of some of the ten stands had been thinned or had received other treatments, only untreated areas within the stands were measured, with the exception that individual tree ages were obtained by counting rings on cut stumps in adjacent areas.

Transects with measurement plots every five chains (330 feet apart) were established in each stand. Among the measurement protocols used were variable radius plots using a 20 BAF prism for trees larger than 8.0 inches DBH. We measured snags, duff concentrations, and fallen trees, as well as live trees. Increment cores were taken to determine tree ages and diameter growth rates. Associated vegetation was observed and recorded.

We measured 1,157 trees (live and dead) in the stands for DBH and distance to plot center, and increment cored for the latest twenty-five-year radial growth rate. Sixty-one trees were either increment cored to the pith for breast height age, or were stumps and their rings counted to determined age. Fire scars were cored to estimate of year of the most recent fire, and earlier fire dates, using the methods of Arno and Sneck, 1977. Fire scars on cut stumps within stands and on adjacent logged stands were also used to estimate fire dates.

TABLE 1. Current conditions of the ten "Areas of Special Interest" stands used to examine stand development histories

Stand Name	Elevation (ft.)	Principal Species[1]	Trees/acre[2]	Basal area (sqft/ac)[3]	Ages (range)[4]	Sampled tree count
South Umpqua Falls	1,680	DF, SP, IC, GF, WRC, BLM	99.2	242.2	46 - 686	109
Five Lakes	2,520	DF, SP, PP, IC, GF	106.7	223.6	43 - 568	123
Pickett Butte	3,000	DF, PP, OWO, IC, PM, GF	113.7	152.0	42 - 681	152
Squaw Flat	2,240	DF, SP, PP, IC, GF, OWO	92.7	197.3	45 - 606	217
Acker Ranch	3,200	DF, IC, SP, GF, PP	95.2	231.4	45 - 587	81
Skookum Pond	3,500	DF, SP, GF, IC, MH, PP	89.6	196.0	48 - 476	49
Whiskey Camp	3,880	DF, SP, IC, GF, PP, MH	88.7	228.6	48 - 586	80
Huckleberry Lake	5,200	SRF, PSF, MH, DF, IC	76.9	218.0	50 - 590	117
Devils Knob	4,400	DF, GF, IC, BLM	58.8	305.7	50 - 993	107
French Junction	4,800	DF, SRF, PSF, MH, IC	65.2	271.1	50 - 942	122

Notes:

1/ DF = Douglas-fir, SP = sugar pine, PP = ponderosa pine, GF = grand fir, IC = incense-cedar, WRC = western red cedar, SRF = Shasta red fir, MH = mountain hemlock, PSF = Pacific silver fir, PM = Pacific madrone, OWO = Oregon white oak, BLM = big-leaf maple

2/ and 3/ Totals for all species, trees >8 in. DBH including snags and fallen trees

4/ estimated, see text

Current diameter and age distributions were calculated and graphed (see Results).

A previously collected sample of 247 trees measured at tree base and breast height was used to develop a linear model to predict unknown breast height diameters from basal diameters. The model derived was:

$$DBH = 2.1720\,(Dbase) - 4.3936 \ln(Dbase) - 0.2418\,(Dbase) * \ln(Dbase) + \varepsilon \qquad (1)$$

where DBH = diameter at breast height, inches; Dbase = diameter at six inches above ground on the uphill side of the tree, inches; and ln indicates natural logarithm. Species and stand differences were not found to be significant predictors of DBH in this data set. Adjusted R^2 was 0.9695.

Trees with known ages were combined with a prior data set (468 trees) from SW Oregon (Dubrasich and Tappeiner 1995). The data were then used to develop three diameter/age models (Zumrawi and Hann 1993). The final form of the models was:

$$Age = \beta_1+\beta_2*(DBH^{\wedge}\beta3)) \qquad (2)$$

where DBH = diameter at breast height, inches and Age = age in years since germination. The three models, with different coefficients, were developed for Douglas-fir, Oregon white oak, and all other tree species combined.

TABLE 2. Age/diameter model statistics

Species	β_1	β_2	β_3	R^2	95% Conf. factor[1]
Douglas-fir	30	0.26	1.85	0.69	± 1.65
Oregon white oak	50	0.53	1.78	0.54	± 1.89
Other species	30	0.26	1.79	0.72	± 1.61

Note 1: Confidence intervals in years are expressed as a factor of diameter in inches. A tree with a DBH of 50 inches and a factor of 2 would have an age confidence interval of ± 100 years.

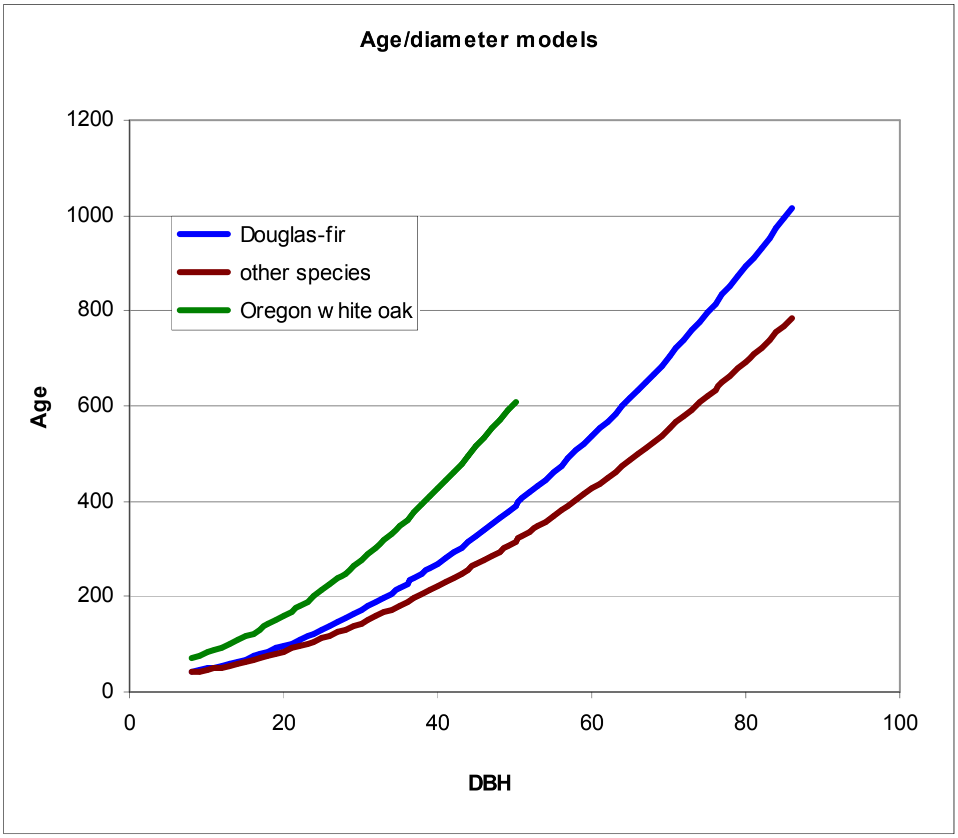

FIGURE 1. Age/diameter models used in the analysis.

Using these models, stand tables (trees per acre by diameter class) were estimated and graphed for the ten stands as they existed in 1825 (see Results). Additional trees were added utilizing a factor of 1.5 to account for missing mortality evidence. We counted and measured snags, fallen trees, and duff concentrations and other indications of former trees, but some trees that died more than 100 years ago may not have any sign left. To correct for missing evidence, each calculated number of trees per acre by diameter class in 1825 in each stand was multiplied by 1.5 to yield the final estimates.

This analysis is limited to trees 8.0 inches DBH and larger. Seedling and sapling densities were not measured because there is no way to determine those of 1825, and hence no comparison with modern seedling and sapling counts is possible.

General Results

Current diameter and age distributions and estimated diameter distributions in 1825 for each of the ten stands are displayed graphically in Figures 2 through 31.

Table 3 lists the density (trees per acre) and basal area changes that have occurred over the last 185 years.

The changes in stand structure have been dramatic. Density of trees greater than 8 inches DBH increased from an average of 20 trees per acre to 90 (from 10 to 35 trees per acre to 60 to 115 trees per acre). Basal area increased 5-fold on average, from 65 square feet per acre to 225 (from 25 to 150 sqft/ac to 150 to 300 sqft/ac).

In 1825 the ten stands were open and park-like with widely spaced trees. By 2010 the ten stands had accumulated from 10 to 20 times the tree biomass they had held 185 years earlier.

The models utilized are not exact. Diameter/age ratios vary considerably: a smaller tree may be old and a larger tree may be young. However, this author has evaluated (measured the ages of) numerous trees in numerous stands, and in my expert judgment (based on observed morphological tree characteristics such as bark thickness, branching, and top conditions) most (more than four-fifths) of the trees present were under 185 years old, confirming the calculated values.

The method utilized included adding half again as many trees in 1825 as were calculated. This generous increase in original densities was in addition to the snags, fallen trees, and duff piles recorded. There may have been smaller trees present in 1825 that died and have disappeared completely. However, even with this factor applied, it is evident that the stands have increased in density enormously over the last 185 years.

In most of the stands the species relative proportions also changed significantly. In 1825 pines and oaks were dominant in stands below 3,800 feet in elevation. Today those same stands are dominated by Douglas-fir, grand fir, and incense-cedar, especially in younger age classes. In higher elevation stands the most abundant species has changed from Shasta red fir to Pacific silver fir.

TABLE 3. Density and basal area changes over 185 years

Stand Name	Trees/acre in 1825	Trees/acre in 2010	**Percent change**	Basal area in 1825	Basal area in 2010	**Percent change**
S. Umpqua Falls	16.5	99.2	**599**	50.9	242.2	**476**
Five Lakes	17.4	106.7	**613**	53.7	223.6	**417**
Pickett Butte	8.8	113.7	**1286**	27.2	152.0	**560**
Squaw Flat	16.6	92.7	**560**	38.4	197.3	**514**
Acker Ranch	24.5	95.2	**388**	53.2	231.4	**435**
Skookum Pond	18.8	89.6	**477**	56.5	196.0	**347**
Whiskey Camp	26.6	88.7	**333**	94.8	228.6	**241**
Huckleberry Lake	14.5	76.9	**530**	49.3	218.0	**442**
Devils Knob	33.6	58.8	**175**	150.5	305.7	**203**
French Junction	24.3	65.2	**269**	87.7	271.1	**309**

Notes: trees over 8 inches DBH only

Stand By Stand Results

South Umpqua Falls

PHOTO 1. A beargrass (*Xerophyllum tenax*) meadow invaded by younger cohort (<185 years old) Douglas-firs at South Umpqua Falls.

The Area of Special Interest at **South Umpqua Falls** is a series of benches and slopes adjacent to and north of the South Umpqua River at approximately 1,680 feet in elevation. Today the stand is dominated by Douglas-fir with some grand fir and incense-cedar. Occasional sugar pines are found on the lower benches and ponderosa pines occur on the upper slopes. A western red cedar grove is found on a wet bench near the eastern edge of the tract. Sword fern (*Polystichum munitum*), vine maple (*Acer circinatum*), and Oregon grape (*Berberis nervosa*) dominate the understory.

Current density is 99.2 trees per acre, and basal area is 242.2 square feet per acre. Seventy percent of those quantities comes from Douglas-fir. Ninety-two percent of the existing trees are less than 185 years old (see Figure 4 and Table 5).

In 1825 the stand was much different. There were only 16.5 trees per acre, over a third of those sugar pines. Basal area was only 50.9 square feet per acre (see Figure 3 and Table 4). The understory had significantly more beargrass (*Xerophyllum tenax*), California hazelnut (*Corylus cornuta*), serviceberry (*Amelanchier alnifolia*), camas

(*Camassia quamash*), and fawn lilies (*Erythronium oregonum*), sparse remnant colonies of which are still present.

The former tree density and remnant species indicate that in 1825 the stand was open and park-like stand with shade intolerant plants – typical of frequent fire savanna/woodlands.

During the past 185 years Douglas-fir, grand fir, and incense-cedar have invaded, along with shade tolerant plants in the understory. The exception to this may be the western red cedar grove which appears to have been established for far longer.

Western red cedar, beargrass, serviceberry, hazel, camas, and other Liliaceae are well-known to be important plants tended and utilized by Native American cultures for thousands of years (Anderson 2005). Abundant deboutage (obsidian flakes), other anthropological evidence [1], and oral histories of Native American elders confirm that human occupancy and use of South Umpqua Falls is indeed ancient. The frequent fires that created the open woodlands there were undoubtedly anthropogenic (see Discussion).

Five Lakes

The Area of Special Interest at **Five Lakes** is an upland basin at approximately 2,520 feet in elevation. The largest of the five lakes is Carman Lake; the others are (today) boggy meadows. Today the stand is dominated by Douglas-fir with extensive grand fir and incense-cedar. Occasional sugar pines and ponderosa pines occur on the gently sloped terrain. A few western red cedars are found adjacent to the boggy, eutrophied lakes. Rhododendrons (*Rhododendron macrophyllum*) dominate the understory, but beargrass and bracken fern (*Pteridium aquilinum*) are also prevalent.

Current density is 106.7 trees per acre, and basal area is 223.6 square feet per acre. Forty-one percent of the density and 64 percent of the basal area is Douglas-fir. Pines account for only two trees per acre. Ninety-two percent of the existing trees are less than 185 years old (see Figure 6 and Table 7).

In 1825 the stand was open and park-like, with only 17.4 trees per acre. Nearly third of those were pines, chiefly sugar pine. Basal area was only 53.7 square feet per acre (see Figure 5 and Table 6). The understory had significantly more beargrass and

[1] Respect for proprieties of the Cow Creek Band of the Umpqua Tribe precludes explication of much of the anthropological evidence present at South Umpqua Falls, which is extensive.

possibly huckleberries (*Vaccinium membranaceum*), remnant colonies of which are still present.

PHOTO 2. An old (300+ years) ponderosa pine with younger cohort (<185 years old) Douglas-firs at Five Lakes. (Note author's hat used for scale).

The former tree density and remnant species indicate that in 1825 the stand was open and park-like stand with shade intolerant plants typical of frequent fire savanna/woodlands. During the past 185 years, in the absence of anthropogenic fire, Douglas-fir, grand fir, and incense-cedar have invaded, along with shade tolerant plants in the understory. The exception to this may be the western red cedars, one of which was measured at over 5 feet DBH.

Four older Douglas-firs at Five Lakes were increment cored with rings counted from 360 to 436 years breast height age. Those trees indicate that many Douglas-firs were present 185 years ago. Sugar pines and ponderosa pines of even older vintages (up to 525 years breast height age) indicate that pines were an important component of the stand in 1825. However, there are few pines younger than 185 years, and few remnant older pines as well. The increase in density has favored more shade tolerant tree species and has caused significant mortality in the older pine cohort.

Only a few of the older trees had fire scars (see Discussion) and none of the younger cohort trees (<185 years old). A cat-faced tree (possibly a culturally modified "hearth tree) had fires scars dated to 135, 160, and 220 years before present (indicating fires in 1875, 1850, and 1790). Possibly more (older) fire dates were indicated on that tree. One hypothesis is that anthropogenic fires were lit in the stand as recently as 1895. That hypothesis is supported by oral histories (Shaffer 1990).

Pickett Butte

PHOTO 3. An old (300+ years) ponderosa pine CMT (culturally modified tree) with younger cohort (<185 years old) Douglas-firs at Pickett Butte (note author's hat used for scale).

The Area of Special Interest at **Pickett Butte** consists of side slopes and terraces at approximately 3,000 feet in elevation in the western-most portion of the Upper South Umpqua Watershed. Today the stand is dominated by Douglas-fir with ponderosa pine, grand fir, incense-cedar, and Pacific madrone (*Arbutus menziesii*). Remnant Oregon white oaks are scattered throughout. Poison oak (*Rhus diversiloba*) and grasses dominate the understory, but camas, and brodiaea (*Brodiaea spp.*) are also present.

Current density is 113.7 trees per acre, and basal area is 150.0 square feet per acre. Sixty-two percent of the density and 63 percent of the basal area is Douglas-fir. Ponderosa pines account for 22.3 trees per acre. Ninety-six percent of the existing trees are less than 185 years old (see Figure 8 and Table 9).

PHOTO 4. Remnant oak/pine savanna at Pickett Butte.

In 1825 the stand was an oak/pine savanna with only 8.8 trees per acre, roughly one-third Oregon white oak, one-third pines (ponderosa and sugar), and one-third Douglas-firs. Basal area was only 27.2 square feet per acre (see Figure 7 and Table 8). The understory was probably grasses and prairie plants, typical of anthropogenically-induced frequent-fire oak savannas in Oregon (Johannessen 1971).

Squaw Flat

The Area of Special Interest at **Squaw Flat** is a hanging plateau with gentle slopes 400 feet above Jackson Creek at approximately 2,240 feet in elevation. Today the stand is comprised mainly of Douglas-fir although Oregon white oaks and ponderosa pines are scattered throughout. Poison oak, snowberry (*Symphorocarpos albus*), ocean-spray (*Holodiscus discolor*), and Oregon grape dominate the understory, but serviceberry, camas, and bracken fern are also present.

Current density is 92.7 trees per acre, and basal area is 197.2 square feet per acre. Seventy-six percent of the density and 62 percent of the basal area is Douglas-fir. Pines (ponderosa and sugar) account for 11.2 trees per acre. Ninety percent of the existing trees are less than 185 years old (see Figure 10 and Table 11).

PHOTO 5. Remnant oak/pine savanna at Squaw Flat (note author's hat used for scale).

PHOTO 6. Conifer biomass accumulation at Squaw Flat.

As was Pickett Butte, in 1825 Squaw Flat was an oak/pine savanna. There were only 16.6 trees per acre with as many oaks and pines (ponderosa and sugar) as Douglas-firs. Basal area was only 38.4 square feet per acre (see Figure 9 and Table 10). The understory was probably grasses and prairie plants. The anthropological evidence is abundant, indicating that human beings occupied and tended Squaw Flat for thousands of years.

In the absence of that human tending a thicket of Douglas-firs has arisen. The cause has not been organized fire suppression but elimination of anthropogenic fire. Fuels loadings today threaten catastrophic fire in the future as a result.

Acker Ranch

PHOTO 7. Five-foot diameter sugar pine at Acker Ranch.

The Area of Special Interest at **Acker Ranch** is a wide ridge top between the South Umpqua River and Jackson Creek sub-basins at approximately 3,200 feet in elevation. Today Douglas-fir predominates with an expanding component of grand fir in the youngest age classes. Remnant sugar and ponderosa pines are scattered throughout. Rhododendron, vine maple, salal, and Oregon grape dominate the understory, and serviceberry, chinquapin (*Castanopsis chrysophylla*), and California hazelnut are minor components. Oregon white oak and Oregon ash (*Fraxinus latifolia*) were in the vicinity although not encountered in the particular stand examined.

Current density is 95.2 trees per acre, and basal area is 231.4 square feet per acre. Forty-nine percent of the density and 61 percent of the basal area is Douglas-fir. Pines (ponderosa and sugar) account for only 2.7 trees per acre. Eighty-eight percent of the existing trees are less than 185 years old (see Figure 12 and Table 13).

In 1825 the stand was open pine parkland. There were only 24.5 trees per acre with as many pines (ponderosa and sugar) as Douglas-firs. Basal area was 53.2 square feet per acre (see Figure 11 and Table 12). The woodland included fruit and nut trees (serviceberry, chinquapin, hazelnut, oak, pines).

The ridge line between the sub-basins was an important travel corridor for the human residents. Fire scars were dated to 1860, 1845, 1835, and 1820 on cut stumps in an adjacent clearcut. Frequent, seasonal, human set fires induced the open pine parkland. In the absence of those traditional practices, species composition has shifted to densely stocked Douglas-fir, grand fir, and incense-cedar.

Many researchers (Lewis 1993, Keter 1995, Bonnicksen 2000, Stewart 2002, Zybach 2003, Anderson 2005, and others) have suggested that the open parklands maintained by anthropogenic tending were in place for thousands of years. The current thicket of invasive trees is very recent imposition on the watershed and landscape (see Discussion).

Skookum Pond

The Area of Special Interest at **Skookum Pond** is a small ridge top basin between the South Umpqua River and Jackson Creek sub-basins at approximately 3,500 feet in elevation. Today the stand is made up principally by Douglas-fir with an expanding component of grand fir and mountain hemlock in the youngest age classes. A few remnant sugar pines and older cohort incense-cedars are scattered throughout. Rhododendron, sword fern, vine maple, salal, and Oregon grape dominate the understory, and serviceberry, chinquapin (*Castanopsis chrysophylla*), and green-leaf manzanita (*Arctostaphylos patula*) are also present. Red alder (*Alnus rubra*) lines the pond where *wakas* or Indian pond lily (*Nuphar lutea ssp. polysepalum*) occurs.

Current density is 89.6 trees per acre, and basal area is 196.0 square feet per acre. Eighty percent of the density and 78 percent of the basal area is Douglas-fir. Pines (ponderosa and sugar) account for only 1.1 trees per acre. Ninety-three percent of the existing trees are less than 185 years old (see Figure 14 and Table 15).

PHOTO 8. Alder, sedges, and water lilies at Skookum Pond.

In 1825 the stand was much more open. There were only 18.8 trees per acre with about one-third pines (ponderosa and sugar), one-third incense-cedars, and one-third Douglas-firs. Basal area was 56.5 square feet per acre (see Figure 13 and Table 14). The 1825 woodland included serviceberry, chinquapin, and beargrass.

The pond may have been an important campsite. Many plants known to be used for food and fiber are still extant at Skookum Pond.

Whiskey Camp

The Area of Special Interest at **Whiskey Camp** is a wide ridge top between Jackson Creek and Beaver Creek at approximately 3,880 feet in elevation. The area is also known as Green Prairie. Today the stand is chiefly Douglas-fir with an expanding component of grand fir and incense-cedar in the youngest age classes. A few sugar and ponderosa pines (about one per five acres) occur. Ocean-spray, sword fern, vine maple, salal, and Oregon grape dominate the understory, and serviceberry and wild currant (*Ribes sp.*) are also present. Fescues (*Festuca spp.*), lupines (*Lupinus spp.*), and wild strawberries (*Fragaria spp.*) are found in open areas known as "balds".

PHOTO 9. Native bunch grasses in a former "bald" at Whiskey Camp.

Current density is 88.7 trees per acre, and basal area is 228.6 square feet per acre. Thirty-three percent of the density and 66 percent of the basal area is Douglas-fir. Grand fir and incense-cedar account for most of the remaining density and basal area. Eighty-seven percent of the existing trees are less than 185 years old (see Figure 16 and Table 17). The 11.3 trees per acre exceeding 185 years old are Douglas-firs.

In 1825 there were only 26.6 trees per acre. Two-thirds were Douglas-firs with a component of grand fir and ponderosa pines. Basal area was 94.8 square feet per acre (see Figure 15 and Table 16). The woodland included serviceberry, chinquapin, and beargrass.

The pockets of trees that were measured constituted a minority of the larger landscape at Whiskey Camp. The majority of the area had very few trees in 1825 but instead was grassy prairie. The soil and climate are conducive to tree growth, as is evidenced by the dense conifer stands that blanket most of the area today. In the precontact era, however, fires must have been so frequent as to preclude tree establishment.

Huckleberry Lake

PHOTO 10. Old (>300 years old) Shasta red fir with invasive Pacific silver fir at Huckleberry Lake (note author's hat used for scale)

The Area of Special Interest at **Huckleberry Lake** is a wide ridge top between Jackson Creek and the North Fork Rogue River at approximately 5,200 feet in elevation. The area is also known as the Rogue-Umpqua Divide, a high elevation ridgeline that extends 20 miles or more to the southwest from the Cascade Crest. Huckleberry Lake is one of the westernmost high elevation sites of the Oregon Cascades.

Today the stand is dominated by Shasta red fir with an expanding component of Pacific silver fir and mountain hemlock in the youngest age classes. Thin-leaved huckleberry (*Vaccinium membranaceum*) predominates in the understory, with numerous secondary species including vanillaleaf (*Achlys triphylla*), mountain-ash (*Sorbus sitchensis*), chinquapin, rhododendron, and Douglas-maple (*Acer glabrum var. douglasii*). The margins of Huckleberry Lake contain aspen (*Populus tremuloides*) and red-osier dogwood (*Cornus stolonifera*).

Current density is 76.9 trees per acre, and basal area is 218.0 square feet per acre. Fifty-four percent of the density and 76 percent of the basal area is Shasta red fir. Pacific silver fir and mountain hemlock account for most of the remaining density and basal area although incense-cedar, Douglas-fir, and subalpine fir (*Abies lasiocarpa* (Hook) Nutt.) and Pacific yew (*Taxus bevifolia* Nutt.) are present in small numbers.

Ninety-one percent of the existing trees are less than 185 years old (see Figure 18 and Table 19). The 6.6 trees per acre exceeding 185 years old are Shasta red firs.

In 1825 the stand was a huckleberry brushfield with scattered Shasta red firs. There were only 14.5 trees per acre. Basal area was 49.3 square feet per acre (see Figure 17 and Table 18).

Anthropological evidence of ancient human use is abundant. Deboutage (obsidian flakes), other anthropological evidence [2], and oral histories of Native American elders confirm that human occupancy and use of Huckleberry Lake is ancient. This ridge is the westernmost high elevation huckleberry site and is easily accessed by a few hours foot travel from winter occupancy sites near Tiller on the South Umpqua River. More remote huckleberry fields to the east near the Cascade Crest were accessible to multiple Native American tribes and nations. Huckleberry Lake thus may have had a greater degree of exclusivity than other summer hunting and gathering sites.

Human tending through frequent burning must have been the principal factor that maintained the huckleberry brushfields by excluding tree invasions. In the absence of such tending over the last 100 years or so, tree invasion has been extensive.

PHOTO 11. Unnamed spring feeding Huckleberry Lake. No modern name, at any rate. This spring has been used by human beings for thousands of years.

[2] Respect for proprieties of the Cow Creek Band of the Umpqua Tribe precludes explication of much of the anthropological evidence present at Huckleberry Lake, which is extensive.

Devils Knob

PHOTO 12. Ancient (>600 years old) Douglas-fir (6 ft DBH) with invasive grand fir at Devils Knob (note author's hat used for scale).

The Area of Special Interest at **Devils Knob** is a ridge top bench between Jackson Creek and Elk Creek (tributary to the South Umpqua River) at approximately 4,400 feet in elevation. The ridge is western extension of the Rogue-Umpqua Divide and overlooks Tiller, OR.

Today the stand contains two distinct age cohorts of Douglas-fir with an expanding component of grand fir youngest age classes. Sword fern, vine maple, Oregon grape, and vanillaleaf dominate the understory, and fescues, lupins, and wild strawberries are found in a few small open areas.

Current density is 58.8 trees per acre, and basal area is 305.7 square feet per acre. Forty percent of the density and 83 percent of the basal area is Douglas-fir. Grand fir makes up the remaining density and basal area. Sixty-three percent of the existing trees are less than 185 years old (see Figure 20 and Table 21). The 22.7 trees per acre exceeding 185 years old are Douglas-firs. In 1825 the stand was more open Douglas-fir parkland. There were 33.6 trees per acre. Basal area was 150.5 square feet per acre (see Figure 19 and Table 20).

Some Douglas-firs at Devils Knob were over 500 years old in 1825. Those very large specimens appear to have been open-grown by virtue of their large branches and broken tops. They contrast with a younger cohort of Douglas-firs that were stand-grown (smaller branches, intact tops, less taper). Some trees in the older cohort exceed 7 feet in diameter, whereas few trees in the second cohort exceed 4 feet DBH. It was not possible to determine ages of the older cohort, but some younger cohort Douglas-firs were cored and range between 200 and 400 years old. Grand firs in the youngest cohort are less than 185 years old.

This "true" old-growth stand is mixed with remnant grassy openings being invaded by Douglas-firs. Grazing by cattle is all that prevents total occupation by trees. In 1825 there were no cattle and it is unlikely that native browsers such as elk could have maintained the openings. Instead, frequent fire must have excluded tree invasion of the prairie areas. Those fires must have been very frequent (every 1 to 5 years) to have been so light-burning that they did not consume the pockets of established Douglas-firs. Those conditions imply intentional, timed, and located human ignitions (see Discussion).

French Junction

PHOTO 12. Remnant thin-leaved huckleberry (*V. membranaceum*) field at French Junction. Note that invading trees are young (<185 years old).

The Area of Special Interest at **French Junction** is a moderately narrow ridge top between the South and North Fork Umpqua River headwaters at approximately 4,800 feet in elevation. French Junction is near the Cascade Crest at one of the easternmost points in the South Umpqua Watershed.

Today the stands consist of older Douglas-fir with a younger cohort of Pacific silver fir and mountain hemlock in the youngest age classes. Shasta red fir and incense-cedar are minor species. Within the stands, beargrass and vanillaleaf dominate, but in more open areas, thin-leaved huckleberry, mountain-ash, chinquapin, rhododendron, Douglas-maple, elderberry (*Sambucus cerulea*), wild currant, serviceberry, grasses, bracken fern, kinnikinnick (*Artostaphylos uva-ursi*), chinquapin, lupines, and many other shrub and herbaceous species.

Current density is 65.2 trees per acre, and basal area is 271.1 square feet per acre. Sixteen percent of the density and 69 percent of the basal area is Douglas-fir. Pacific silver fir accounts for 69 percent of the density but only 29 percent of the basal area (see Figure 22 and Table 23). Incense-cedar, Shasta red fir, red alder and Pacific yew are present in small numbers.

In 1825 the stand was a huckleberry brushfield with scattered and clumped very large Douglas-firs (huckleberry parkland). There were 24.3 trees per acre. Basal area was 87.7 square feet per acre (see Figure 21 and Table 22). Roughly one-third of the trees were less than 15 inches DBH and one-third greater than 30 inches DBH. Most of the large trees were Douglas-firs with occasional Shasta red firs.

As at Huckleberry Lake, anthropological evidence of ancient human use is abundant. The Kalmath Trail, a major travel route for thousands of years, is thought to have passed through or close to French Junction. Food and fiber plants known to have been used by Native Americans are abundant.

Human tending through frequent burning must have been the principal factor that maintained the huckleberry brushfields by excluding tree invasions. In the absence of such tending over the last 100 years or so, tree invasion has been extensive.

Discussion

Introduction

Over the last 185 years the landscapes of the Upper South Umpqua Watershed have experienced significant changes in forest structure, species relative proportions, biomass accumulation, fire hazard, wildlife guilds, and landscape dynamics. These changes are geologically recent, have arisen as a result of disruption of the historical (precontact) forest influences and effects imparted by resident human beings over the last 10,000 years.

Selection of the 185-year reconstruction target is appropriate because in the Upper South Umpqua Watershed the application of traditional (millennia old) ecological management techniques was still occurring in 1825, but diminished in intensity over the next 25 years. The forests of today are rebounding from thousands of years of intensive human management. The degree of vegetative change from 1825 to today, which is considerable, reflects the degree of influence that resident human beings had over the vegetation in the precontact Holocene.

The changes in stand structure since 1825 have been dramatic. Density of trees greater than 8 inches DBH increased from an average of 20 trees per acre to 90 (from 10 to 35 trees per acre to 60 to 115 trees per acre). Basal area increased 5-fold on average, from 65 square feet per acre to 225 (from 25 to 150 sqft/ac to 150 to 300 sqft/ac).

In 1825 the ten stands were open and park-like with widely spaced trees. By 2010 the ten stands had accumulated from 10 to 20 times the tree biomass they had held 185 years earlier. In 1825 pines and oaks were predominant in stands below 3,800 feet elevation. Today those same stands are dominated by Douglas-fir, grand fir, and incense-cedar, especially in younger age classes. In higher elevation stands the most prevalent species has changed from Shasta red fir to Pacific silver fir.

By implication the forest development pathways have also changed.

1825 Map Vegetational Zones

- **Oak zone**

Includes prairie, shrublands, oak savanna, oak woodlands mostly below 2,400 feet elevation. Ponderosa pine and Douglas-fir were important components, but the presence of remnant ancient oaks is diagnostic.

Prairie lands in the **oak zone** were composed of grasses and often contained areas of extensive camas. Hazel, serviceberry, lomatiums, lilies, lupines, and a host of other prairie plant species were widespread or found in patches.

Pickett Butte is a good example of the oak zone. In 1825 there were only 8.8 trees per acre, roughly one-third Oregon white oak, one-third pines (ponderosa and sugar), and one-third Douglas-firs, at Pickett Butte.

Today there are 113.7 trees per acre, a 12-fold increase. Basal area has increased 560 percent. Douglas-fir dominates and the oak are dying out and have died out over large portions of the **oak zone**.

- **Pine zone**

Includes meadows, shrublands, pine dominated savannas, and pine-dominated mixed conifer woodlands from roughly 2,400 feet to 3,800 feet elevation. Ponderosa and sugar pine were the dominant tree species but Douglas-fir, incense-cedar, and pockets of western red cedar were also prevalent, especially along riparian corridors.

The understory was often beargrass, and serviceberry was also an important component.

Five Lakes is a good example of the **pine zone**. In 1825 there were only 17.4 trees per acre, and nearly third of those pines, chiefly sugar pine. Basal area was only 53.7 square feet per acre.

Today there are 106.7 trees per acre, a 6-fold increase. Basal area has increased 417 percent. Douglas-fir dominates and the pines are dying out.

- **Douglas-fir zone**

Includes grassy balds, shrublands, Douglas-fir dominated savannas, and Douglas-fir dominated mixed conifer woodlands from roughly 3,800 feet to 5,000 feet elevation. Douglas-fir was the principal tree species, but incense-cedar, and grand fir also occurred. Mountain hemlock, ponderosa pine, and Shasta red fir were present in low numbers.

The understory was often dominated by beargrass, serviceberry, chinquapin, and huckleberries. Fescue bunchgrasses were an important component in treeless "balds".

Whiskey Camp is a good example of the **Douglas-fir zone**. In 1825 the stand was open conifer parkland. There were only 26.6 trees per acre; two-thirds were Douglas-firs with a component of grand fir and ponderosa pines. Basal area was 94.8 square feet per acre.

Today there are 88.7 trees per acre, a 3-fold increase. Basal area has increased 241 percent. Douglas-fir is still the most prevalent species, although there is a strong component of grand fir in younger age classes.

- **Subalpine zone**

Includes grassy balds, shrublands, Shasta red fir dominated savannas, and Shasta red fir dominated mixed conifer woodlands above roughly 5,000 feet in the watershed. Shasta red fir was the dominant tree species, but Douglas-fir, Pacific silver fir, incense-cedar, and mountain hemlock, were present in low numbers.

The understory was principally beargrass and huckleberries. Nearly treeless huckleberry fields were thousands of acres in size.

Huckleberry Lake is a good example of the **Subalpine zone**. In 1825 the stand was a huckleberry brushfield with scattered Shasta red firs. There were only 14.5 trees per acre. Basal area was 49.3 square feet per acre.

Today there are 76.9 trees per acre, a 5-fold increase. Basal area has increased 442 percent. Shasta red fir is still the principal tree species, but there is a strong component of Pacific silver fir in younger age classes. Huckleberry cover is much reduced because the species (*V. membranaceum*) is not shade tolerant.

In all zones the 1825 landscape had far fewer trees. Stands had only one third to one twelfth the number of trees (larger than 8 inches DBH). A sizeable proportion of the landscape had no trees at all. Treed areas were open and park-like with widely spaced, uneven aged trees ranging from recently established to over 500 years old.

Forest Development Pathways

Prairies, brushfields, oak savannas, conifer savannas, and open, park-like forests are elements commonly included in descriptions of precontact forests in the watershed (Leiberg 1903, Carloni 2005); in the immediate region (Leiberg 1903, Habeck 1961, Johannessen *et al.* 1971, Lewis 1973, Shaffer 1990, Keter 1995, LaLande and Pullen 1999, Bailey and Kertis 2002, Williams 2002, Sensenig 2003, Zybach 2003, Anderson 2005, Lake 2005, Tappeiner *et al.* 2007, Fritschle 2008, and others), and in forests in other locales (Pyne 1982, Robbins 1993, Covington and Moore 1994, Bonnicksen 2000, Stewart 2002, Keane *et al*. 2006, Fowler and Konopik 2007, Kay 2007, and others). Those findings are based (variously) on explorer and pioneer journals, oral histories of Native American elders, and stand reconstructions such as this one.

Thus the prairie-savanna-open-forest vegetation condition is thought to have been widespread in precontact landscapes of the West. It is also thought to be an ancient landscape condition: many thousands of years old.

Evidence suggests that the precontact forests followed a different dynamic than modern forests. In this paper we use “forest development pathways” to describe the dynamics of the precontact forests instead of “succession”, because plant “succession” dynamics apparent in modern forests were suspended, perhaps for thousands of years.

Besides the large body of testimonies by witnesses and historians, several lines of empirical evidence support the hypothesis that precontact open forest conditions were of long vintage (rather than a temporary transitional stage).

- The older cohort trees have the morphology of open-grown trees (Poage and Tappeiner 2002). Wide growth rings near the pith, low height-diameter ratios (< 50), crown retention, large limbs or evidence of large limbs on the lower bole, are all indicators of open-grown conditions. Older cohort trees were not stand-grown trees — they were savanna-grown trees that had little or no tree-to-tree competition (Dubrasich 2010). Stand grown trees are present today in the younger cohort and have narrow growth rings, high height-diameter ratios (> 70), small limbs, and rapid crown recession, all indicating within-stand competition.

- The older cohort trees are uneven aged. Older cohort trees aged in this study ranged from ~150 years to 526 years, but we were unable to increment bore the very large trees (4 to 7+ feet DBH) that we encountered. Even so, the wide age ranges within the stands are evidence that individual trees and the open stand structure were persistent.

- The noted decline in populations of prairie-dependent species such as the Mardon skipper (*Polites mardon*) and Siskiyou short-horned grasshopper (*Chloealtis aspasma*) (pers. comm. G. Brenner). The major threat to these insects is the loss of a large percentage of the prairie forbs upon which they depend. Presumably they became established over a long period of prairie-savanna-open-forest conditions.

- Archaeological sites with camas ovens (with charcoal that can be carbon dated) indicate "intense and continuous [occupation] between 3000 and 300 years ago" by Native Americans (Connolly 1991). Camas is a prairie and savanna plant. As discussed below, the lifeways of the aboriginal residences included extensive use of anthropogenic fire which perpetuated prairies, savannas, and open forests.

Thus the evidence suggests that the prairies, savannas, and open forests have been persistent vegetation types in the Upper South Umpqua Watershed (and other areas) for the last few thousand years at least.

The ancient, persistent, open forests and savannas must have followed a much different set of forest development pathways than are in place today. Modern forests in the area do not exhibit the same forest structure, and hence do not have the same forest dynamics.

Tree Recruitment – The 1825 stands -- with ~20 trees per acre and with persistent trees to 500 years old -- must have recruited one (persistent 8-inch DBH) tree per acre every 25 years. That recruitment rate is exceedingly slow. Since ~1850 the stands in the Upper South Umpqua Watershed have recruited one 8-inch tree per acre per year, or 25 times faster than the precontact rate (see Figures 3, 6, 9, 12, 15, 18, 21, 24, 27, and 30).

***Tree species relative proportion*s** – In 1825 pines and oaks constituted two-thirds of the trees in the oak and pine zones. Today pines and oaks constitute less than 10 percent of the trees in those zones and are almost absent in the youngest size classes. Douglas-fir dominates, as might be expected, since that species is well-known to out-compete the others (and certainly has over the last ~150 years in the stands studied). Curiously, Douglas-fir was present (and grew well) in the precontact stands yet was a minor species.

Biomass accumulation – Precontact stands accumulated biomass very slowly. In contrast, biomass today in the stands in the Upper South Umpqua Watershed have more than 10 times the gross (live and dead) biomass per unit area that they carried in 1825. Presumably gross photosynthetic productivity has not changed (diameter growth rates were actually greater in 1825, but due to open, competition-free, individual tree growing conditions, not a greater site productivity). Biomass certainly has accumulated over the last 185 years. But biomass apparently did not accumulate (at the nearly same rate) in precontact forests.

The forest development pathways of precontact forests were fundamentally different from today's forest dynamics. One or more critical environmental drivers or forcing factors has changed since 1825.

A growing body of forest scientists hypothesize that the critical factor that changed is fire — specifically the absence since ~1850 of frequent, seasonal, intentional, anthropogenic (human-set) fire (Habeck 1961, Johannessen *et al.* 1971, Pyne 1982, Keter 1995, LaLande and Pullen 1999, Lewis 1999 Bonnicksen 2000, Pyne 2000, Bailey and Kertis 2002, Stewart 2002, Zybach 2003, Anderson 2005, Carloni 2005, Lake 2005, Kay 2007, and others).

Anthropogenic Fire

Fire is a chemical process (rapid exothermic oxidation), but exogenous (outdoor) fire is biologically-driven. The fuel in a forest fire is biomass. Without biological fuels (and oxygen), there would be no exogenous combustion. Forest fires consume biomass, living and dead, and alter (disturb) vegetation. Hence fire is an important factor in biological forest development.

Wildfires differ in their intensity and severity, frequency, areal extent, ignition source, and human intentionality (purpose). These characteristics are governed by interacting factors that include fuel loading, fuel dryness or flammability, fuel continuity across the terrain, topography, ignition location, ignition timing, ignition frequency, weather, and season, and in the case of anthropogenic fire, the skill and intent of the human setting the fire.

Fire intensity and severity – Fires differ in their intensity – technically the rate at which a fire produces heat, expressed in terms of temperature or heat yield (Hartford, and Frandsen 1991) – and severity, the degree to which fires consume the available biomass (Bormann *et al.* 2008) and kill living plants (especially trees).

Precontact fires were effective at removing the biomass; precontact biomass loadings were a fraction of modern loadings. Precontact fires were less effective at killing established trees, though the survivors were few in number and well-distributed.

Modern forest fires (in modern dense forests) are often intense and severe, killing all the living trees, aka *stand-replacing* (Tappeiner *et al.* 2007). They also tend to leave a considerable amount of newly dead, unconsumed biomass behind (Bonnicksen 2008).

PHOTO 13. Mortality from the 2009 Boze Fire near French Junction. Note the high density and stand-grown morphology of the trees in this even-aged (~140 years old) post-Contact stand.

Fire frequency – Precontact fires in the Upper South Umpqua Watershed were (in the aggregate) less intense and less severe than modern fires, yet they were effective at consuming the annual biomass production. That is because precontact fires were frequent (a fire return interval less than ~15 years in SW Oregon).

Infrequent fires (a fire return interval greater than ~15 years in SW Oregon) tend to be stand-replacing. The long hiatus between fires allows biomass to accumulate, resulting in well-fueled, intense, and severe fires. Even-aged stands seed in following such fires. Precontact stands were uneven-aged and many of those trees have multiple fire scars, indicating that they survived multiple low-severity fires. Because of the short return interval, frequent fires are more effective at consuming the available biomass than are infrequent fires. Annual biomass production does not accumulate over decades, other than in widely-spaced green trees.

Based on fire scar evidence, Sensenig (2003) found a composite fire frequency ranging from 3 to 10 years in the Oregon Cascades south of the study area. Sensenig also found a group composite fire frequency (grouping fires scars where fires were aged to within +/- 3 years) ranging from 7 to 13 years. Lake (2005) reported an average period of 2 years between fires in the Klamath Mountains.

Fire frequencies derived from fire scars most likely underestimate true fire frequency (overestimate the fire return interval), especially when fires are frequent (Stephens 2010). Hence in 1825 in the Upper South Umpqua Watershed, the fire return interval probably ranged from 1 to 10 years, depending on location in the watershed.

Fire extent – Fire extent, the acreage burned per year, is the reciprocal of the burning rate (Van Wagner *et al.* 2006). For instance, if the fire return interval (averaged across point samples) is 100 years, then on average 1 percent of the total area burns every year. If the return interval is 10 years, then on average 10 percent of the total area burns every year. If the fire cycle is 3 years, then one-third of the total area burns each year, on average.

Despite the fact that frequent fires on average burn more acreage each year (than infrequent fires do), individual fires in a frequent fire regime are generally smaller than individual infrequent fires.

If there is a long hiatus between fires, biomass accumulates. Available fuels increase, as does the continuity of fuels across the landscape. Megafires (>100,000 acres) can and do result (Williams 2010). Frequent fires, in contrast, are limited by availability and continuity of fuels and tend to remain small. Frequent fires are thus small and numerous as well as frequent, and a frequent fire regime tends to create a patchy rather than a uniform vegetation pattern across the landscape.

In the precontact watershed fires were small, frequent, and burned in light fuels. Multiple fires may have burned at the same time, with contact on perimeters, but if a single fire is defined as arising from a single unique ignition point, then most fires in the precontact Upper South Umpqua Watershed were probably less than 100 acres in size.

Ignition source – Based on data from 1970 to 2002 the Umpqua National Forest reports a lightning-fire ignition rate of 59/400,000 ha per year, or 0.0382 lightning fires per square mile per year (Kay 2007). The Upper South Umpqua Watershed is 231,931 acres or 362.4 square miles, which implies an average of 13.8 lightning fires per year in the study area.

To burn one-third of the watershed each year (a 3-year fire return interval), each lightning fire would have to burn an average of 5,600 acres, or 50 to 100 times the expected average fire size in a frequent fire regime in this landscape. There was, however, another ignition source present in the watershed for thousands of years: human beings.

Boyd (1999a) estimated a Willamette Valley Kalapuyan aboriginal population density of 0.44 inhabitants per square mile. That density is consistent with other estimates of populations in precontact North America (Denevan 1992, Mann 2005, Kay 2007). In the Upper South Umpqua Watershed a density of 0.44 people per square mile yields a population count of 161.

Human populations in the study area were undoubtedly greater in the summer and fall than during winter months. In late precontact time, the number of people in the area might reasonably be estimated at 1,000 or 2,000 individuals at the height of harvests, fishing, or trade gatherings. In earlier times, when regional populations may have been greater, seasonal visitation numbers were likely even greater (pers. comm. B. Zybach).

In reviewing the literature, Kay (2007) estimates a Native American purposeful burning rate of 10 fires/person per year. That translates to 10,000 to 20,000 purposeful anthropogenic fires per year in the precontact watershed, dwarfing the lightning ignition rate of 13.8 fires per year. Kay summarizes:

> Using the lowest published estimate of native people in the United States and Canada prior to European influences (2 million) and assuming that each individual started only 1 fire per year—potential aboriginal ignition rates were 2.7–350 times greater than current lightning ignition rates. Using more realistic estimates of native populations, as well as the number of fires each person started per year, potential aboriginal ignition rates were 270–35,000 times greater than known lightning ignition rates. Thus, lightning-caused fires may have been largely irrelevant for at least the last 10,000 years. Instead, the dominant ecological force likely has been aboriginal burning. [*Kay (2007) p. 16*]

Providing further evidence of anthropogenic ignition, Lake (2005) notes that fire scars dating to 1628 in the Klamath Mountains indicate (by position of the scar relative to growth rings) that one-fourth of the fires were late winter-spring, when there are (and were) no lightning ignitions.

Henry T. Lewis noted in his *An Anthropological Critique* in Omer Stewart's *Forgotten Fires* (Stewart 2002):

> Research over the last thirty years has clearly demonstrated the significance of indigenous burning practices and the important ways that hunting-gathering technologies have differed from natural fire regimes. …
>
> Even where lightning fires occur with high frequency—such as California, the American Southwest, and semiarid parts of Australia—indigenous people neither could nor would have depended upon the distribution of natural fires. To assume that lightning ignitions, even in these most fire-adapted environments, are sufficient for human purposes is most naïve, furthering the misguided idea that hunter-gatherers could only exploit what nature provided. Setting fires in specific places, at designated times of the year, and under conditions that best sustain resource habitats and serve human goals is far more important than whether there is an abundance (or poverty!) of lightning fires that might somehow inadvertently serve human goals. In terms of what we now know about the ecologies of natural and prescribed fires, the important question is no longer why hunter-gatherers would have set fires but, rather, why on earth they would not have done so. [*Lewis in Stewart (2002) p. 33*]

Fire intentionality – Some anthropogenic fires may have been "accidental", but in the main they were intentional: deliberately set in a particular place at a particular time by a skilled practitioner, informed by long cultural experience and traditional ecological knowledge in order to achieve specific land management objectives (Habeck 1961, Johannessen *et al.* 1971, Pyne 1982, Keter 1995, Bonnicksen *et al.* 1999, LaLande and Pullen 1999, Lewis 1999, Bonnicksen 2000, Stewart 2002, Zybach 2003, Anderson 2005, Carloni 2005, Lake 2005, Kay 2007, and others).

Indians had various purposes for landscape burning including (Bonnicksen *et al.* 1999, Kay 2000):

- Stimulate the production of edible and craft fiber plants, promoting the growth of shoots, flowers, fruits, nuts, bulbs, etc.
- To thin, prune, weed, and to discourage insects and diseases on preferred food and fiber plants.
- To increase browse and forage for game animals.
- To drive game animals and facilitate hunting.
- To increase visibility for hunting and the detection of enemies and predators.
- To open and maintain trails.
- For warfare and signaling
- To mitigate fire hazards and prevent catastrophic megafires (which could have severely handicapped human survival).
- To create firewood

Firewood was used for cooking and warming. Hearth fires were maintained (kept burning 24/7). In a landscape inhabited by fuel collectors for thousands of years, there was likely limited availability of dead, down wood. One Indian practice (observed by Lewis and Clark) was the setting afire of individual green (and pitchy) conifers to burn off the needles and kill the tree, thereby producing firewood for future use. Individual tree and patch selection burning was likely also practiced as a weeding tool in huckleberry fields (Minore *et al.* 1979), acorn orchards, and other crop areas.

The very few trees that survived the frequent fires when seedlings, and were not deliberately set afire for firewood when larger, were likely protected through fuel and fire management (reduction of fuels from the base of large nut-bearing oaks and pines, for instance).

Purposeful burning guided the forest development pathways of precontact forests. Frequent anthropogenic fire, practiced across the watershed for millennia, reduced the rate of tree recruitment, selected nut tree species over non-food tree species, and consumed the available biomass at a rate that precluded most biomass accumulation.

The historic forest development pathways that led to old-growth trees in Upper South Umpqua Watershed were human-mediated. Many of today's old-growth trees (>185 years old) were individually selected for survival by the indigenous residents, and thus have human heritage value. Abandoning the forests of today to "natural" stand-replacing fires is an alteration of the historical forest development pathways and as a result will not lead to old-growth tree development in the future (Dubrasich and Tappeiner 1995, Poage 2001).

The Anthropogenic Mosaic

Purposeful anthropogenic fire over thousands of years not only modified the forest development pathways within stands, it established a persistent placement of human-modified vegetation types throughout the watershed.

The indigenous residents used fire systematically for agro-ecological purposes such as the creation and maintenance of berry patches, camas meadows, acorn and pine nut orchards, madia fields, home sites, gathering and collecting sites, hunting copses, and fishing sites (Zybach 2007). Vegetation types such as remnant meadows, savannas, and parklands are historically human-modified and maintained, traditional Native American cultural sites. Medicine wheels and other Native American religious sites may be found within the Upper South Umpqua Watershed (pers. comm. C. Jackson). Many of the old-growth trees show signs of Native American use as hearth trees and bark-peeled trees (Dubrasich and Tappeiner 1995, Keane *et al.* 2006).

Oak savanna extended from the foothills and valleys below the study area to ~2,400 feet, and in some cases as high as 3,200 feet (i.e. Acker Ranch). The savanna was diverse, however, with hazel, serviceberry, lomatiums, camas, and food and fiber plant species widespread or found in patches. Sugar and ponderosa pine open woodlands occupied mid slopes. At higher elevations beargrass and huckleberries occurred in large, maintained fields. Western red cedar occurred in patches that may be thousands of years old. Madia fields, bunch grass prairies, fern brakes, and riparian meadows were found throughout (LaLande and Pullen 1999, Carloni 2005, Zybach 2007).

Each of these patches was managed under a specialized anthropogenic fire schedule based on traditional knowledge. An extensive, frequently burned trail system interlaced the entire watershed, with access to any location no more than one or two days walk from any other (Carloni 2005, see also main report, ***South Umpqua Precontact Reference Conditions Study***).

The system of maintained patches and trails is consistent with the "yards and corridors" pattern described by Lewis (1973) and others. Of particular note is the work by Carloni (2005) in the adjacent North Umpqua Watershed. He modeled the most ergonomic (not too steep) and least cost (shortest) travel routes between ten known archaeological sites. The model was field-validated, leading to on-the-ground discovery of ancient trails and additional sites, including an ancient summer village. Dr. Carloni summarizes:

> Intentionally or not, humans have been initiators of broadcast burning in nearly every habitat they have encountered worldwide (Pyne, 2001), and there is a long local history of burning for agro-ecological purposes in southwestern Oregon … A growing body of evidence documents the influence of Native Americans on their landscapes through the use of systematic landscape fire …
>
> Pacific Northwest native societies were deeply integrated into their landscapes, and used a wide variety of materials collected over extensive areas (Lewis, 1993; Boyd, 1986; Beckham and Minor, 1992; Blackburn and Anderson, 1993; LaLande, 1995; Williams, 2001). But local material cultures persist only to the extent that key species and habitats on which they depend remain abundant, productive and resilient (Perlin, 1989; Diamond, 2005). Archaeological evidence from the Umpqua indicates that material cultures remained relatively unchanged for approximately 2000 years before contact (Isaac Barner, pers. comm., 2000) suggesting that the stewardship practices of recent peoples were sustainable …

> Historic Indian-set fires tended toward higher frequencies and lower intensities with regular intervals separating them relative to lightning sparked fires (Boyd, 1999; Lewis and Fergeson, 1999; Williams, 2001). [*Carloni (2005) 100-101*]

The Upper South Umpqua Watershed was thus a cultural landscape comprised of an anthropogenically-induced vegetation mosaic. Similar landscape conditions were widespread regionally and indeed throughout the Western Hemisphere in pre-Columbian times. Frequently burned, historical cultural landscapes (prairies, savannas, open woodlands) have been described for other parts of Oregon (Leiberg 1903, Habeck 1961, Johannessen 1971, Dickman 1978, Wilson *et al.* 1991, Robbins 1993, Boyd 1999, LaLande and Pullen 1999, Bailey and Kertis 2002, Carloni 2005, Zybach 2002 2003 2007 2008a 2008b), California (Lewis 1973, Blackburn and Anderson 1993, Keter 1995, Anderson 2005, Lake 2005, Norman 2007, Fritschle 2008), Washington (Peter and Shebitz 2006, Storm and Shebitz 2006, Anderson 2009, Shebitz *et al.* 2009), British Columbia (Turner 1991, Deur and Turner 2006, Vellend *et al.* 2008), the Rocky Mountains (Barrett and Arno 1982, Ostland *et al.* 2005, Keane *et al.* 2006,), the Great Basin (Simms 2008), the Southwest (Raish 2005, Pyne 2009), the Southeast (Fowler and Konopik 2007), the Northeast (Abrams and Nowacki 2008), throughout North America (Lewis 1982, Pyne 1982, Bonnicksen *et al.* 1999, Bonnicksen 2000, Stewart 2002, Williams 2003) and in South and Central America (Denevan 2001, Mann 2005, Heckenberger *et al.* 2007, Woods 2009).

The anthropogenic mosaic of the precontact study area was not unique but a recapitulation of the cultural landscapes in the region, continentally, and indeed worldwide, manipulated by indigenous land use technologies, chief among them purposeful fire, and sustained over thousands of years prior to the modern era.

The recent (~150 years) alterations of the forest development pathways (and concomitantly the forest structures) in the Upper South Umpqua Watershed are a result of the elimination of historical human land management.

Boyd (1999a, 1999c) documents smallpox epidemics in Oregon in c. 1775 and 1801-1802, and malaria epidemics beginning in 1831 and every summer thereafter. By 1841, Boyd estimates, the Kalapuyan population in the Willamette Valley had fallen from a pre-smallpox count of 14,760 to 600, or 96 percent. Pre-Columbian populations throughout the New World collapsed by similar percentages (Denevan 1992, Mann 2005). The effects to native cultures in Oregon were devastating, but landscape burning continued on a declining basis until “immigrant settlers put an end to the practice in the mid 1840s” (Boyd 1999a).

Some native burning continued in the Upper South Umpqua Watershed, however, perhaps to as late as 1905. Susan Crispen Shaffer (1990) of the Cow Creek Band of the Umpqua Tribe of Indians noted that:

> Indians were the first environmentalists. Our ties to our Mother Earth are different than those of the people who came after us. We have always understood that we must protect the resources that sustain us. The fall burning practices to keep our forests clean were common. This was to keep the forest clear of fallen logs, underbrush, and other debris that collected. It also served the purpose of killing unwanted bugs and insects, harmful to the forest. By keeping the forest floor clean there was an assurance of plentiful food for the game animals which were the main food source for many tribes. It also provided a clear view of the animals for the hunters. Fish habitat was protected as well. In my Great-grandfather's diaries, he has many entries of burning. My Great-uncle [Bob Thomason] continued this practice and when the Forest Service came to the Tiller Ranger District here in the Umpqua National Forest in Douglas County, Oregon, their system was not to burn. Here was this old Indian fellow that they knew was continuing to do the burning – what to do with him? They ended up hiring him so that they could keep an eye on him! Some old timers maintain that he sometimes still had a little smoke going here and there!
>
> When I was a very little girl, I remember asking Uncle Bob, "When do you do the burning?" His reply was always, "When the time is right." He would often go out in the field, away from the house and sniff the air, also wet his finger and hold it up (although there was no wind that I could perceive), and say, "Not yet" or "It's time." I never knew on what he based his reasoning. The fires were set annually, but I'm sure on a rotating basis. As for the time of the year, it would appear that some burning was done in the early Spring, although the bulk of it was in the Fall, perhaps after the first rain, for even in aboriginal times the annual fires were recognized as a way to balance the ecology. After Fall fires, there was a quick greening, providing food for the forest animals. [*Shaffer (1990)*]

It is likely that intensive traditional management of the watershed (including frequent anthropogenic fires) declined significantly after the epidemics of the late 1700s, and almost entirely by 1850.

Climate

There are many reasons why "climate change" is not responsible for the alterations in forest development pathways in the Upper South Umpqua Watershed over the last 185 years:

- No significant climate change has taken place (beyond normal variation) since 1825 (Easterbrook 2008), yet wholesale changes in the forest development pathways have occurred.

- Precontact cultural landscapes with anthropogenic prairies, savannas, and open, park-like forests occurred across climate zones (indeed throughout the Western Hemisphere), indicating that the vegetation types (and hence the precontact forest development pathways) were not climate-dependant.

- No new open, park-like forests are arising in any climate, even where lightning fires are allowed to burn. Federal land management agencies have implemented "prescribed natural fires" and "wildfires used for resource benefit" in an attempt to "reintroduce natural fire". Yet in no case (regardless of climate zone) have open forest structures developed (such as those extant in the study area 185 years ago).

- Anthropogenically-induced prairies, savannas, and open, park-like forests were persistent vegetation types for thousands of years despite historical perturbations in global climate such as the Little Ice Age and the Medieval Warm Period (Soon *et al.* 2003).

- Other explanations for the alteration in forest development pathways (i.e. the elimination of anthropogenic fire) are more robust and well-documented, and are free of the nagging anomalies noted above.

Carloni (2005) reported strong evidence against climate as a controller of fire frequency prior to 1850 in the North Umpqua Watershed. He compared precipitation history and fire history with the ages of existing trees to test which factors (climate or fires) influenced tree recruitment, and whether climate history and fire history were correlated. They were not:

> Fire scar frequencies from 1590 to 1820 show no relationship to precipitation. However, from 1850 to 1950 a significant negative correlation ($p = 0.005$) exists between climate and scar frequency. These results suggest that in post-aboriginal times [but not earlier] high rainfall years are associated with fewer fires than low rainfall years…
>
> Tree recruitment from 1590 to 1820 is again uncorrelated with yearly precipitation. …
>
> [N]o correlation is evident between fire scar frequency and tree recruitment in the years from 1590 to 1820. From 1850 to 1939, however, dramatic positive correlations exist between fire scar frequencies and tree origins…
>
> This suggests that the recently observed short pulses of even-aged recruitment following wildfires (Pickett and White, 1985; Oliver and Larson, 1990; Bonnicksen, 2000) may be more of a post-aboriginal phenomenon. [*Carloni (2005) 73-76, 90*]

Conclusions

1. In 1825 vegetation types in the Upper South Umpqua watershed consisted of prairie, oak savanna, sugar and ponderosa pine open woodlands, and high elevation shrublands.

2. Since 1825 the changes in stand structures have been dramatic. Density of trees greater than 8 inches DBH increased an average of 450 percent and basal area increased 5-fold. By 2010 the ten stands had accumulated from 10 to 20 times the tree biomass they had held 185 years earlier. In most of the stands the species relative proportions also changed significantly. In 1825 pines and oaks were dominant in stands below 3,800 feet in elevation. Today those same stands are dominated by Douglas-fir, grand fir, and incense-cedar, especially in younger age classes.

3. By implication the forest development pathways have changed since 1825. Tree recruitment and biomass accumulation rates have increased, and tree species relative proportions have changed (from dominance by pine and oak to dominance by Douglas-fir).

4. Human-set fire has played an important role in the development of these stands. Frequent anthropogenic fires maintained uneven-aged, sparsely stocked, open and park-like stands for thousands of years. The elimination of anthropogenic fire over the last 150 years is the key factor that has altered development pathways and forest structure and composition.

5. The anthropogenic fire regime was typified by frequent, low-severity fires of limited individual extent, which cumulatively burned over the entire watershed every 1 to 10 years. At a landscape scale the result was maintenance of an (ancient) anthropogenic mosaic of agro-ecological patches. In the absence of the purposeful fires set by skilled practitioners, the anthropogenic mosaic has been invaded and obscured by (principally) Douglas-fir. Infrequent, a-historical, catastrophic stand-replacing wildfires have replaced low severity fires due to the massive build-up of biomass (fuels).

These findings should be useful in:

- Advancing understanding of forest dynamics, historical human influences, and historical landscape geography,

- Informing the maintenance and preservation of historic cultural landscape features -- the anthropogenic landscape patterns are cultural legacies by themselves (Lake 2005),

- Evaluating and mitigating catastrophic fire hazards and risks, and

- Informing restoration efforts, where restoration means active management to recover historical cultural landscapes, historical forest development pathways, and traditional ecological stewardship to achieve resiliency to fire and insects, provide sustainable resource products and services, and to preclude and prevent a-historical catastrophic fires that degrade and destroy myriad resource values (Charnley *et al.* 2008, Dubrasich 2010b).

From Carloni (2005):

> Since material cultures often reflect their landscapes (e.g. bedrock mortars in acorn country; woven nets, weirs, and traps where salmon run), stable human cultures infer stable landscape resources. And since local material culture was stable for at least 2000 years in southwestern Oregon (Beckham and Minor, 1992), then the pre-Euro-American socioecological system represents the last known stable state.
>
> If we desire a predictable suite of ecosystem goods and services that are comparable (but not necessarily equivalent) to those available to native managers, then historic ranges of ecosystem conditions represent reasonable management sideboards. Given that the historic landscape… is to a great degree the product of active aboriginal management, it will take active management on the part of land stewards to recreate and maintain analogous conditions. [*Carloni (2005) p. 154*]

Addendum: Native American Voices Regarding Anthropogenic Fire

Native American land managers are well aware of their heritage. The following excerpts from Evergreen Magazine, Winter 2005-2006, entitled “Forestry in Indian Country: Models of Sustainability for Our Nation’s Forests?” express expert perspective and application of traditional ecological knowledge:

From A School of Red Herring by Gary S. Morishima, Technical Advisor, Quinault Nation:

> Tribes have been managing natural resource systems for thousands of years, but protecting tribal legacies for the future is no simple task. The resources that are essential to sustain tribal cultures are coming under relentless attack from a variety of economic and political forces … To a great extent, these threats stem from the introduction of an invasive species several centuries ago … Europeans.

From Sovereignty, Stewardship, and Sustainability by Larry Mason, Project Coordinator for the Rural Technology Initiative at the College of Natural Resources, University of Washington:

> Tribes are known to have been managers of natural resources for 10,000 years or more. In many areas of the United States, ecosystems found by early European settlers were not virgin wilderness untouched by the hand of man, but were instead forests altered through time by many generations of Natives that burned, pruned, sowed, weeded, tilled, and harvested to meet their requirements for firewood, fish and game, vegetal foods, craft supplies, and building materials. Periodic underburning not only produced desirable vegetative conditions but reduced fuel accumulations that might otherwise sustain intense fire. A severe fire in a tribal territory would have meant not only loss of property, resources, and lives, but also a long-term disaster for the well-being of the community.

From The Yakama’s Prescription for Sustainable Forestry by Markian Petruncio, Ph.D., Administrative Forester, Yakama Nation, and Edwin Lewis, Forest Manager, BIA, Yakama Agency:

> Forest restoration implies that a forest will be returned to a prior condition. Nineteenth-century forest conditions on the Yakama Reservation appeared to be more sustainable than present conditions. For example, open pine stands were maintained in a healthy condition by frequent, low-intensity fires. The forestry program [on Yakama Nation lands] is using historic species composition and stand densities as references for restoration of forest health. … The pathway to sustainable forestry requires proactive management.

From The Forest Is In Your Hands by Nolan Colegrove, Sr., Forest Manager, Hoopa Valley Tribal Council, Forestry Division:

> We tended and managed the forest with many tools that were created from nature, but the most effective tool was controlled fire. … The tending of the forest with the use of fire produced annual crops which provided the daily necessities of the people; but what also occurred, by conducting low intensity burns annually for hundreds of years, was that the condition of the forest was healthy and in balance.

From Ecosystem Management and Tribal Self-Governance on the Flathead Indian Reservation, Montana by Jim Durglo, Forest Manager, Confederated Salish and Kootenai Tribes:

> The Tribes understood that both Indian-lit and lightning fires shaped the forest. Here in the Northern Rockies, fire, more than any other factor except climate, shaped the structure of our forest. It determined the kinds and ages of trees, how close together they grew, and the number and types of openings that existed. … From the stories of elders, the historical accounts of early Europeans, and the findings of modern scientific research, we know that Indians have been purposefully burning in the area for at least 7,000 years.

From The Gift of Fire by Germaine White, information and education specialist for the Confederated Salish and Kootenai Tribes of the Flathead Reservation, Montana:

> As Salish and Pend d'Oreille people, our view of fire was and is quite different from the modern western view. In our tradition, fire is a gift from the Creator brought to us by the animals. We think of it as a blessing, that if used respectfully and in a manner consistent with our traditional

knowledge, will enrich our world. This belief explains our long tradition (12,000 years plus) of spring and fall burning …

On my last trip into the Bob Marshall Wilderness Area with one of our tribal elders, Harriet Whitworth, we followed the trails she had followed seventy years previous with her mother and grandmother, trails her family had followed for multiple generations. When we arrived at Big Prairie on the South Fork of the Flathead River, Harriet described what it was like when she was a little girl. She said it was a big, open, park-like area where there were enormous ponderosa pine trees, an abundance of grass, and many animals … [with] many clearings, a series of prairies in one place, and Harriet talked of how beautiful it was when she was a child.

Now there is only a little bit of a camp and small prairie or meadow left, and the big pine trees are crowded with Douglas-fir trees. Being there in that place and listening to the stories of how it used to look just a single elder's lifetime ago showed me in a vivid way what it means to exclude fire from the landscape.

All the above from Petersen, James, ed. Forestry in Indian Country: Models of Sustainability for Our Nation's Forests? Evergreen Magazine, Winter 2005-2006.

And finally, some commentary on the inclusion of anthropology in ecosystem studies:

Neither culture nor nature is static, and hunter-gatherer groups had a substantial impact on their environment. Because of their relatively simple technologies, their profound effects on the environment are often overlooked or minimized. The peoples who inhabited the North Fork basin during prehistoric times were, however, far more than passive observers of the environment within which they lived. The concept of a pristine wilderness untouched by human activities during the prehistoric era is not valid for this region. Aboriginal groups affected their environments through their subsistence and cultural activities. Thus, a dynamic interaction existed between the environment and the lifeways of the aboriginal inhabitants of the region. ...

I believe that cultural anthropologists, historians, and archaeologists with their distinct perspectives can help to provide a deeper understanding of past environmental trends needed for ecosystems management. Without an understanding of historical ecological processes and past human land-use activities, any attempt to make recommendations about the management of today's National Forests from an ecosystem management perspective will be inadequate.

From Keter, Thomas S. 1995. Environmental History and Cultural Ecology of the North Fork of the Eel River Basin, California. USDA For. Ser. R5-EM-TP-002.

I am struck by what appears to me as an intellectual bias; derived not from intent but from the inevitable inertia developed within a particular field of study. For example, fire and vegetation histories are freely considered in terms of possible correlations to lightning strike history, solar flare activity, and other physical phenomena, while the exceptionally well-documented human influences on fire history are often regarded as too speculative for serious consideration. Our perceptions are limited by our understanding; there is much to be gained by developing a rich critical understanding and appreciation of the tools, models, and theories of other disciplines.

From Anthropological and Archaeological Perspectives on Native Fire Management of the Willamette Valley. 2000. Thomas J. Connolly, Museum of Anthropology, University of Oregon Paper presented at the 81st Annual Meeting of the American Association for the Advancement of Science, Pacific Division (Symposium: Fire History in the Pacific Northwest: Human and Climatic Influences), June 11-14, 2000, Ashland, Oregon.

Every ecosystem in North America has been affected in some way by a fire regime… manipulated by indigenous people. Much forest science, including ecological classifications of vegetation types, arose from observation of forest that were essentially in transition from conditions of indigenous fire management to post-colonial fire suppression. Our understanding of forest processes may thus be based on an anomalous, transitional landscape”

From Kimmerer, R.W.; Lake, F.K. 2001. The role of indigenous burning in land management. Journal of Forestry. 99(11): 36–41.

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Figures and Tables

Figures 3 and 4. 1825 and current diameter distributions, **South Umpqua Falls**

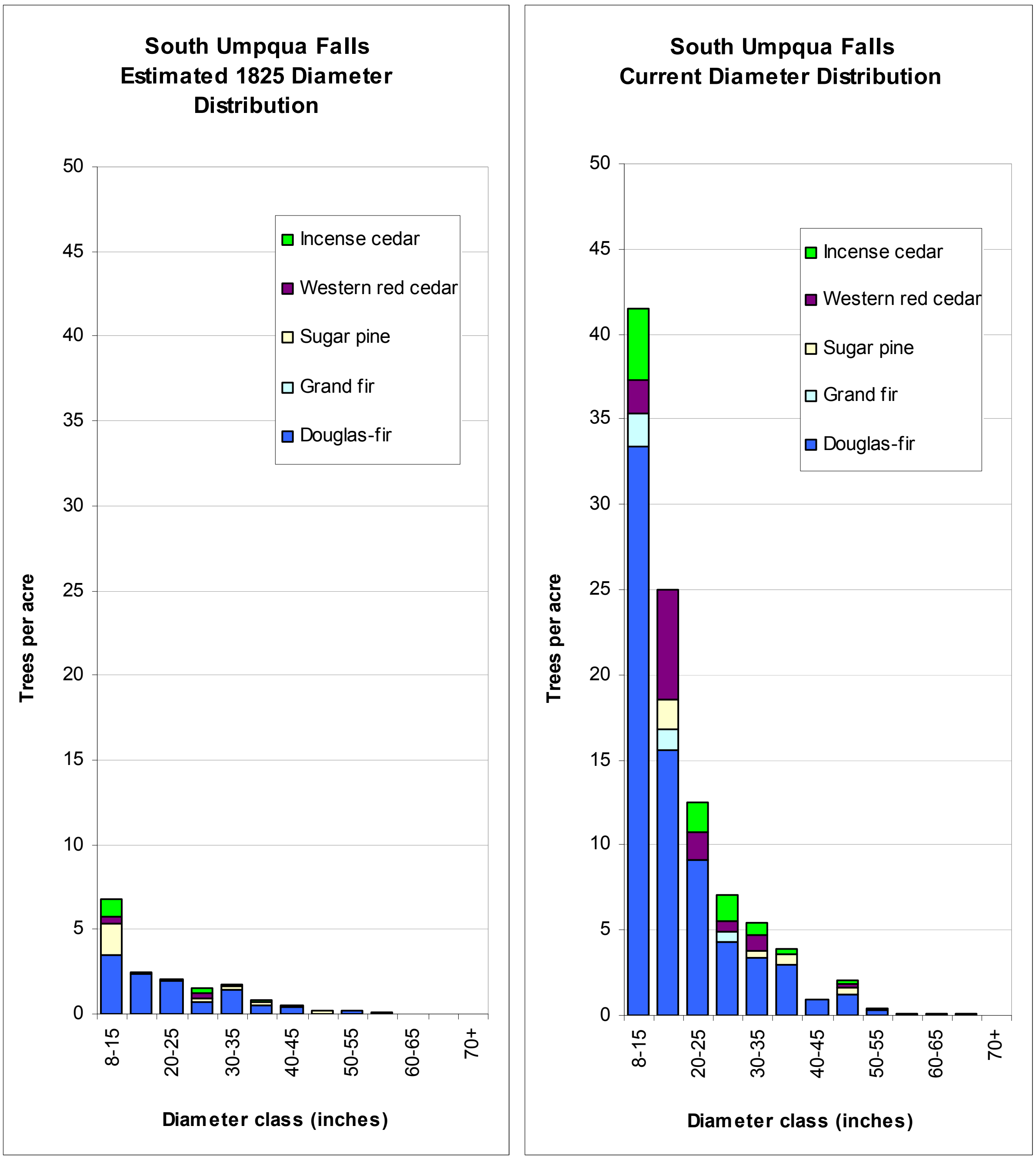


Table 4. Estimated trees per acre in 1825, by species, **South Umpqua Falls**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	3.5	0.0	1.8	0.0	0.5	1.0	0.0	6.8
15-20	2.3	0.0	0.1	0.0	0.1	0.1	0.0	2.5
20-25	1.9	0.0	0.1	0.0	0.1	0.1	0.0	2.1
25-30	0.7	0.0	0.3	0.0	0.3	0.3	0.0	1.5
30-35	1.4	0.0	0.3	0.0	0.1	0.1	0.0	1.8
35-40'	0.5	0.0	0.2	0.0	0.1	0.1	0.0	0.8
40-45	0.4	0.0	0.1	0.0	0.1	0.0	0.0	0.5
45-50	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.2
50-55	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.2
55-60	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	11.1	0.0	2.9	0.0	1.0	1.5	0.0	
							Grand Total	16.5

Table 5. Current trees per acre by species, **South Umpqua Falls**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	33.4	1.9	0.0	0.0	2.0	4.2	0.0	41.5
15-20	15.6	1.3	1.7	0.0	6.5	0.0	0.0	25.0
20-25	9.2	0.0	0.0	0.0	1.6	1.8	0.0	12.5
25-30	4.3	0.6	0.0	0.0	0.6	1.5	0.0	7.1
30-35	3.4	0.0	0.4	0.0	0.9	0.8	0.0	5.5
35-40'	3.0	0.0	0.6	0.0	0.0	0.3	0.0	3.9
40-45	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
45-50	1.3	0.0	0.4	0.0	0.2	0.2	0.0	2.0
50-55	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.4
55-60	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
60-65	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
65-70	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	71.6	3.7	3.4	0.0	11.7	8.8	0.0	
							Grand Total	99.2

Figures 5 and 6. 1825 and current diameter distributions, **Five Lakes**

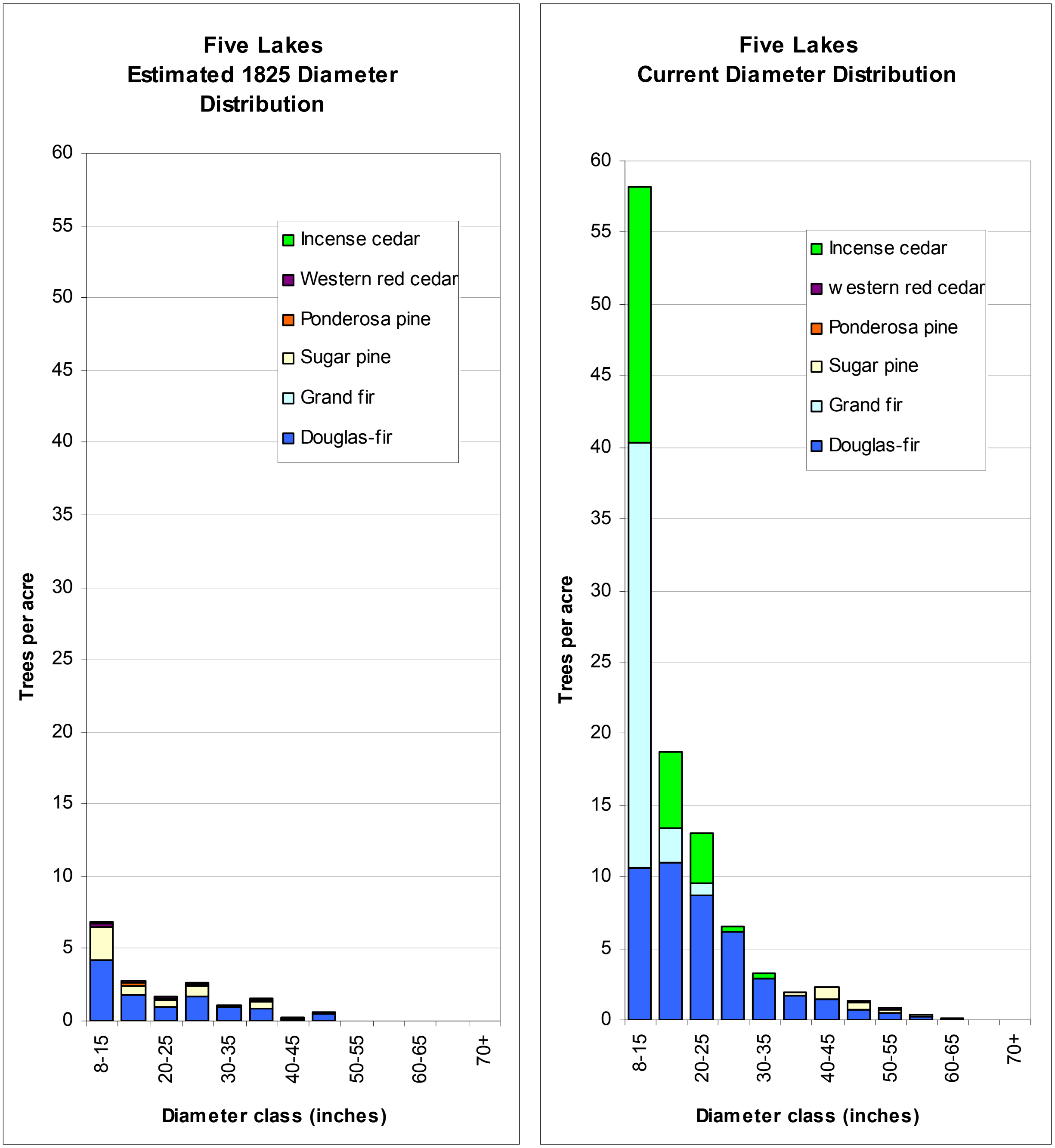


Table 6. Estimated trees per acre in 1825, by species, **Five Lakes**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	4.2	0.0	2.3	0.1	0.2	0.1	0.0	6.8
15-20	1.8	0.0	0.6	0.3	0.1	0.0	0.0	2.7
20-25	1.0	0.0	0.5	0.1	0.2	0.0	0.0	1.7
25-30	1.6	0.0	0.7	0.2	0.1	0.0	0.0	2.6
30-35	0.9	0.0	0.1	0.1	0.1	0.0	0.0	1.1
35-40'	0.8	0.0	0.5	0.1	0.2	0.0	0.0	1.6
40-45	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.3
45-50	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.6
50-55	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
55-60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	10.9	0.0	4.9	0.7	0.8	0.1	0.0	
							Grand Total	17.4

Table 7. Current trees per acre by species, **Five Lakes**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	10.6	29.7	0.0	0.0	0.0	17.8	0.0	58.2
15-20	11.0	2.5	0.0	0.0	0.0	5.3	0.0	18.7
20-25	8.7	0.8	0.0	0.0	0.0	3.5	0.0	13.0
25-30	6.1	0.0	0.0	0.0	0.0	0.4	0.0	6.5
30-35	2.9	0.0	0.0	0.0	0.0	0.3	0.0	3.3
35-40'	1.7	0.0	0.3	0.0	0.0	0.0	0.0	2.0
40-45	1.5	0.0	0.7	0.0	0.0	0.0	0.0	2.2
45-50	0.8	0.0	0.5	0.1	0.0	0.0	0.0	1.4
50-55	0.5	0.0	0.2	0.0	0.1	0.0	0.0	0.9
55-60	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.4
60-65	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	44.2	33.0	1.9	0.1	0.1	27.3	0.0	
							Grand Total	106.7

Figures 7 and 8. 1825 and current diameter distributions, **Pickett Butte**

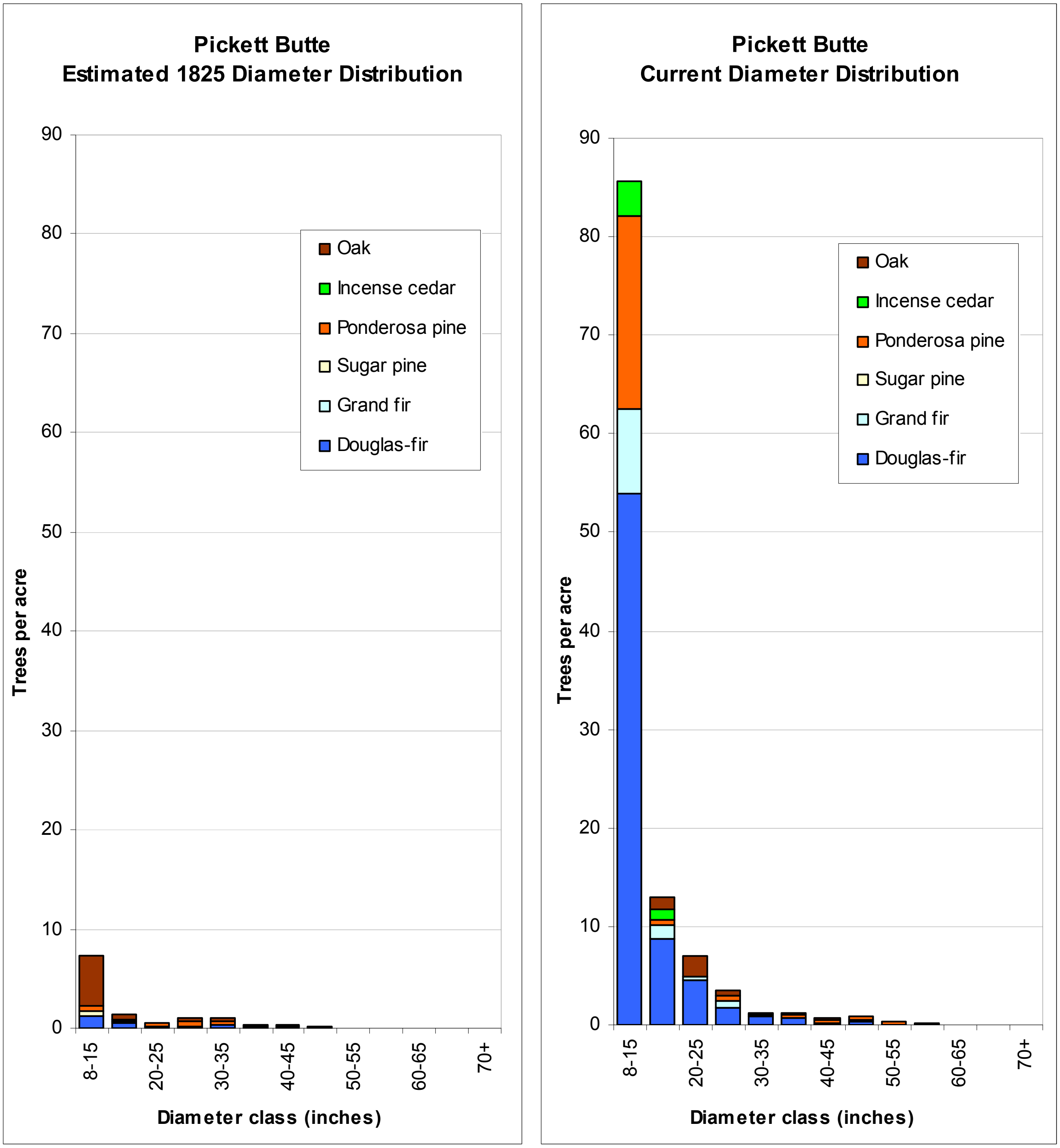


Table 8. Estimated trees per acre in 1825, by species, **Pickett Butte**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	1.2	0.0	0.5	0.6	0.2	0.1	1.0	3.6
15-20	0.6	0.0	0.1	0.3	0.1	0.0	0.4	1.4
20-25	0.2	0.0	0.1	0.3	0.2	0.0	0.1	0.8
25-30	0.1	0.0	0.1	0.5	0.1	0.0	0.3	1.0
30-35	0.4	0.0	0.1	0.3	0.1	0.0	0.2	1.0
35-40'	0.1	0.0	0.1	0.1	0.1	0.0	0.2	0.5
40-45	0.1	0.0	0.1	0.0	0.1	0.0	0.2	0.4
45-50	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1
50-55	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
55-60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	2.7	0.0	1.0	2.1	0.7	0.1	2.3	
							Grand Total	8.8

Table 9. Current trees per acre by species, **Pickett Butte**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	53.9	8.7	0.0	19.5	0.0	3.4	0.0	85.6
15-20	8.8	1.3	0.0	0.6	0.0	1.0	1.3	13.0
20-25	4.6	0.3	0.0	0.0	0.0	0.0	2.1	7.0
25-30	1.7	0.7	0.0	0.6	0.0	0.0	0.5	3.4
30-35	0.9	0.0	0.0	0.2	0.0	0.0	0.2	1.3
35-40'	0.7	0.0	0.0	0.4	0.0	0.0	0.1	1.2
40-45	0.1	0.0	0.0	0.4	0.0	0.0	0.1	0.6
45-50	0.4	0.0	0.2	0.3	0.0	0.0	0.0	0.9
50-55	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.4
55-60	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	71.4	11.1	0.2	22.3	0.1	4.5	4.3	
							Grand Total	113.7

Figures 9 and 10. 1825 and current diameter distributions, **Squaw Flat**

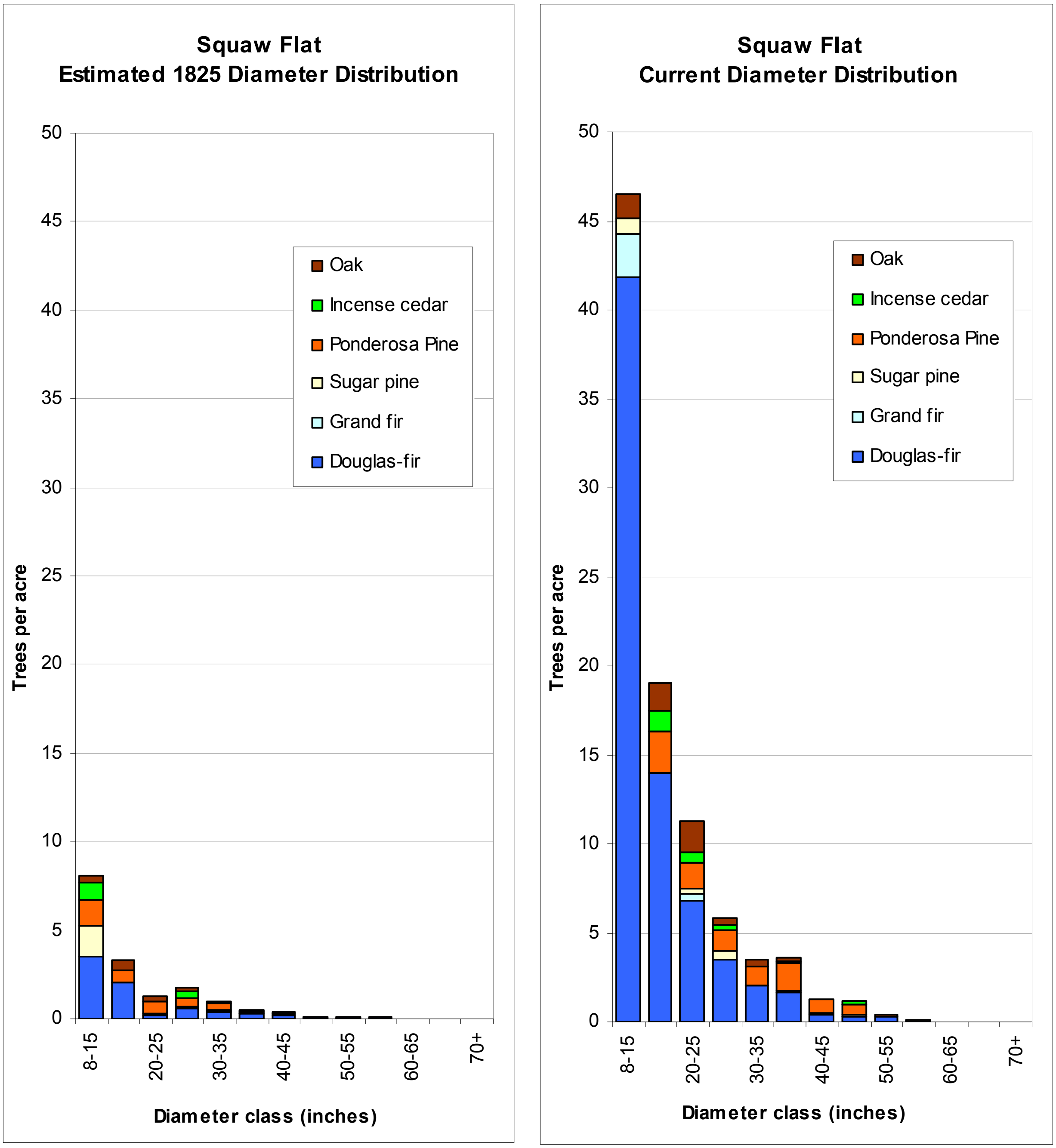


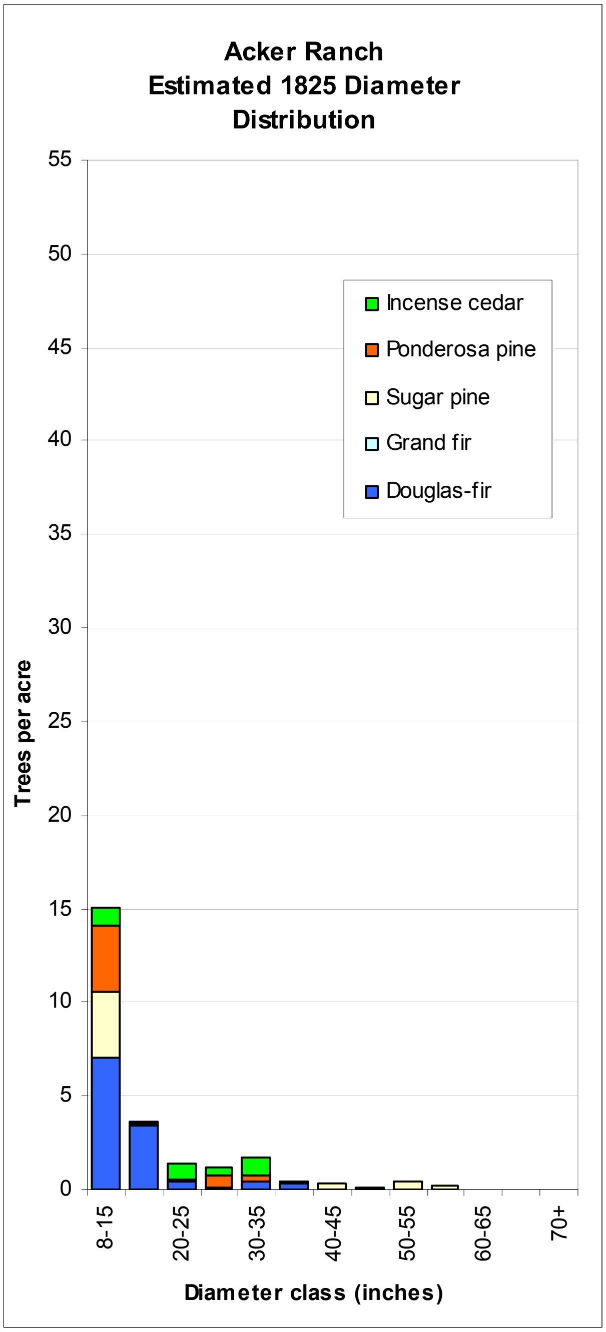
Table 10. Estimated trees per acre in 1825, by species, **Squaw Flat**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	3.5	0.0	1.8	1.4	0.0	1.0	1.0	8.7
15-20	2.0	0.0	0.1	0.6	0.0	0.2	0.1	2.9
20-25	0.2	0.0	0.1	0.7	0.0	0.1	0.1	1.0
25-30	0.5	0.0	0.1	0.6	0.0	0.3	0.3	1.9
30-35	0.3	0.0	0.1	0.4	0.0	0.1	0.1	1.0
35-40'	0.3	0.0	0.1	0.1	0.0	0.1	0.1	0.5
40-45	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.3
45-50	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1
50-55	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1
55-60	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	7.2	0.0	2.4	3.7	0.0	1.7	1.5	
							Grand Total	16.6

Table 11. Current trees per acre by species, **Squaw Flat**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	41.8	2.5	0.9	0.0	0.0	0.0	1.4	46.6
15-20	14.0	0.0	0.0	2.4	0.0	1.1	1.6	19.1
20-25	6.8	0.4	0.3	1.5	0.0	0.6	1.7	11.2
25-30	3.5	0.0	0.4	1.2	0.0	0.3	0.4	5.9
30-35	2.1	0.0	0.0	1.1	0.0	0.0	0.3	3.5
35-40'	1.6	0.0	0.1	1.6	0.0	0.1	0.1	3.5
40-45	0.4	0.0	0.1	0.8	0.0	0.0	0.0	1.3
45-50	0.3	0.0	0.1	0.6	0.0	0.2	0.0	1.2
50-55	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.4
55-60	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	70.7	2.9	2.0	9.2	0.0	2.4	5.6	
							Grand Total	92.7

Figures 11 and 12. 1825 and current diameter distributions, **Acker Ranch**



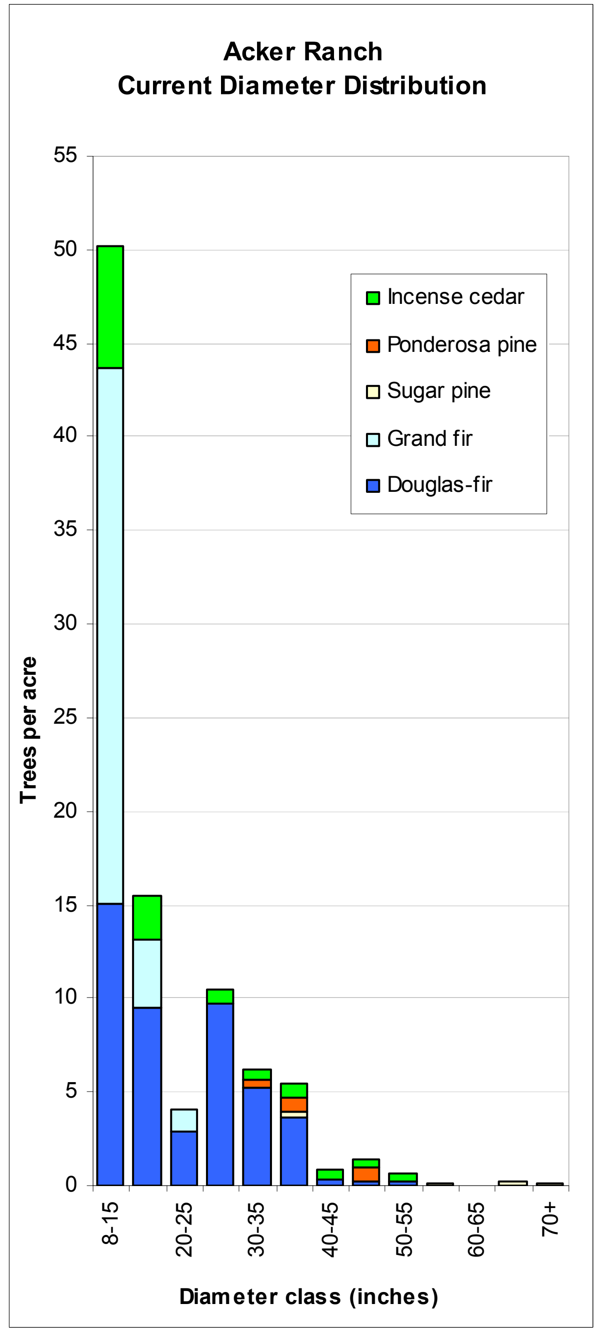


Table 12. Estimated trees per acre in 1825, by species, **Acker Ranch**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	7.0	0.0	3.6	3.5	0.0	1.0	0.0	15.1
15-20	3.5	0.0	0.1	0.1	0.0	0.1	0.0	3.6
20-25	0.5	0.0	0.1	0.1	0.0	0.8	0.0	1.4
25-30	0.1	0.0	0.1	0.7	0.0	0.4	0.0	1.2
30-35	0.4	0.0	0.1	0.3	0.0	0.9	0.0	1.7
35-40'	0.3	0.0	0.1	0.1	0.0	0.1	0.0	0.5
40-45	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.3
45-50	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1
50-55	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.4
55-60	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.2
60-65	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	11.9	0.0	4.7	4.7	0.0	3.3	0.0	
							Grand Total	24.5

Table 13. Current trees per acre by species, **Acker Ranch**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	15.1	28.6	0.0	0.0	0.0	6.5	0.0	50.2
15-20	9.6	3.6	0.0	0.0	0.0	2.3	0.0	15.5
20-25	2.8	1.2	0.0	0.0	0.0	0.0	0.0	4.1
25-30	9.8	0.0	0.0	0.0	0.0	0.7	0.0	10.4
30-35	5.2	0.0	0.0	0.5	0.0	0.5	0.0	6.2
35-40'	3.6	0.0	0.4	0.7	0.0	0.7	0.0	5.4
40-45	0.3	0.0	0.0	0.0	0.0	0.6	0.0	0.9
45-50	0.3	0.0	0.0	0.7	0.0	0.5	0.0	1.4
50-55	0.2	0.0	0.0	0.0	0.0	0.4	0.0	0.6
55-60	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2
70+	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Totals by sp.	46.8	33.4	0.9	1.8	0.0	12.2	0.0	
							Grand Total	95.2

Figures 13 and 14. 1825 and current diameter distributions, **Skookum Pond**

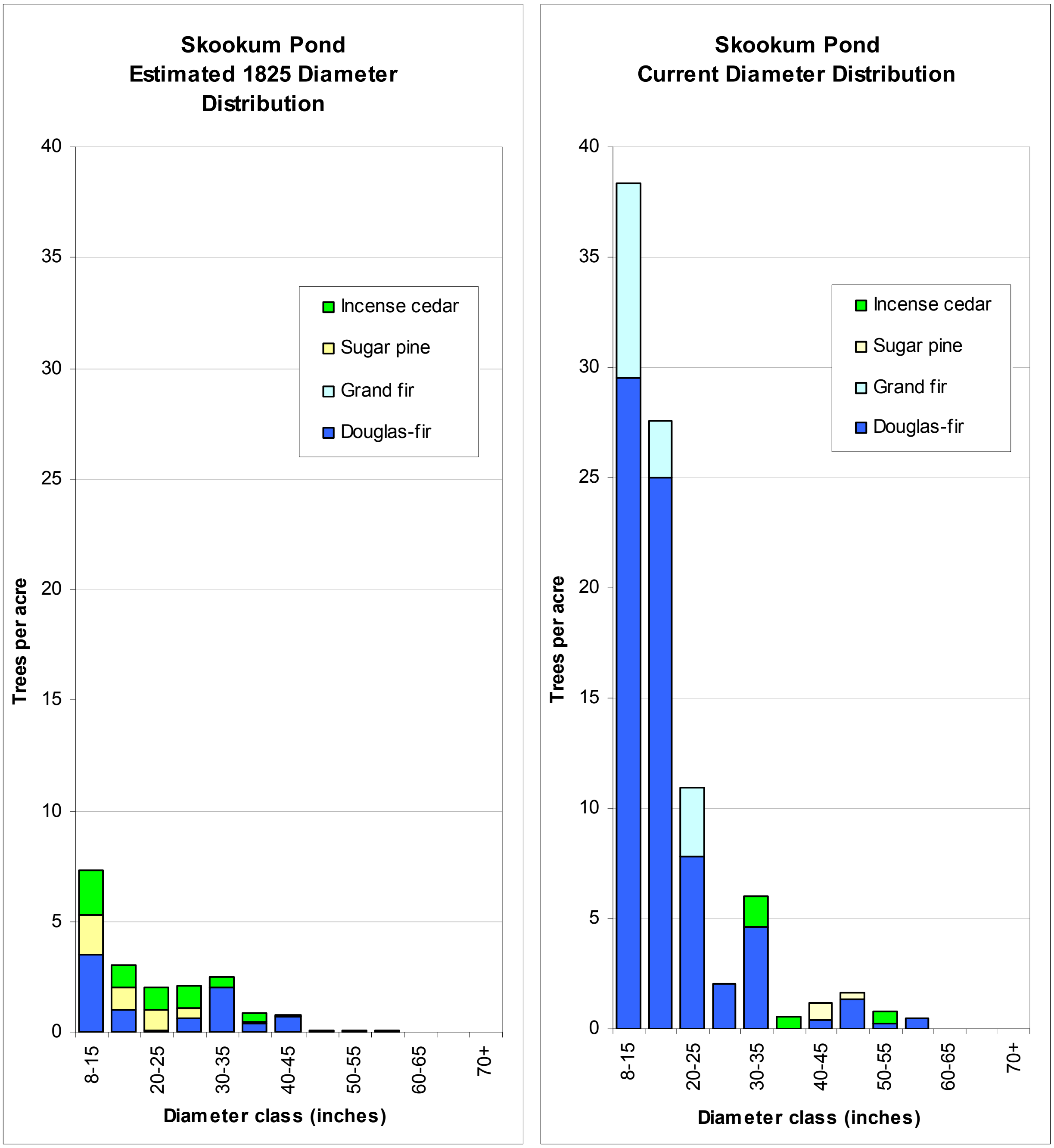


Table 14. Estimated trees per acre in 1825, by species, **Skookum Pond**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	3.5	0.0	1.8	0.0	0.0	2.0	0.0	7.3
15-20	1.0	0.0	1.0	0.0	0.0	1.0	0.0	3.0
20-25	0.1	0.0	1.0	0.0	0.0	1.0	0.0	2.1
25-30	0.6	0.0	0.5	0.0	0.0	1.0	0.0	2.1
30-35	2.0	0.0	0.1	0.0	0.0	0.4	0.0	2.5
35-40'	0.4	0.0	0.1	0.0	0.0	0.4	0.0	0.8
40-45	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.8
45-50	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1
50-55	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1
55-60	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	8.4	0.0	4.5	0.0	0.0	5.8	0.0	
							Grand Total	18.8

Table 15. Current trees per acre by species, **Skookum Pond**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	29.6	8.8	0.0	0.0	0.0	0.0	0.0	38.4
15-20	25.0	2.5	0.0	0.0	0.0	0.0	0.0	27.6
20-25	7.8	3.1	0.0	0.0	0.0	0.0	0.0	10.9
25-30	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
30-35	4.6	0.0	0.0	0.0	0.0	1.4	0.0	6.0
35-40'	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
40-45	0.4	0.0	0.8	0.0	0.0	0.0	0.0	1.2
45-50	1.3	0.0	0.3	0.0	0.0	0.0	0.0	1.6
50-55	0.3	0.0	0.0	0.0	0.0	0.5	0.0	0.8
55-60	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	71.6	14.5	1.1	0.0	0.0	2.4	0.0	
							Grand Total	89.6

Figures 15 and 16. 1825 and current diameter distributions, **Whiskey Camp**

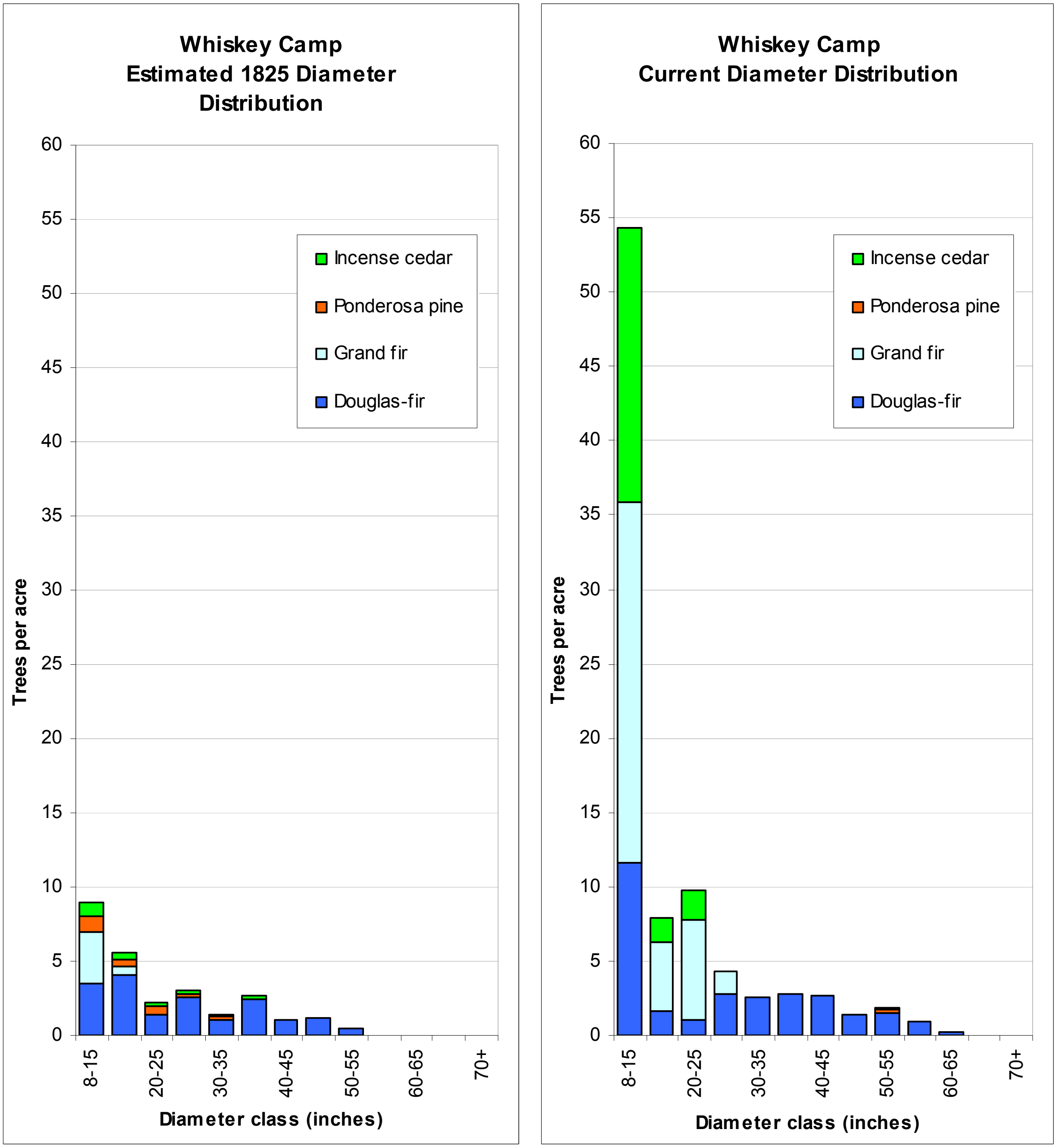


Table 16. Estimated trees per acre in 1825, by species, **Whiskey Camp**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	3.5	3.5	0.0	1.0	0.0	1.0	0.0	9.0
15-20	4.1	0.5	0.0	0.5	0.0	0.5	0.0	5.6
20-25	1.4	0.0	0.0	0.5	0.0	0.3	0.0	2.2
25-30	2.6	0.0	0.0	0.2	0.0	0.2	0.0	3.0
30-35	1.1	0.0	0.0	0.2	0.0	0.1	0.0	1.4
35-40'	2.5	0.0	0.0	0.0	0.0	0.3	0.0	2.7
40-45	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1
45-50	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2
50-55	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4
55-60	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	17.8	4.0	0.0	2.4	0.0	2.4	0.0	
							Grand Total	26.6

Table 17. Current trees per acre by species, **Whiskey Camp**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	Western red cedar	incense cedar	white/black oak	Totals by DBH class
8-15	11.5	24.3	0.0	0.0	0.0	18.6	0.0	54.4
15-20	1.6	4.7	0.0	0.0	0.0	1.6	0.0	7.9
20-25	1.1	6.7	0.0	0.0	0.0	2.0	0.0	9.7
25-30	2.8	1.5	0.0	0.0	0.0	0.0	0.0	4.3
30-35	2.5	0.0	0.0	0.0	0.0	0.0	0.0	2.5
35-40'	2.7	0.0	0.0	0.0	0.0	0.0	0.0	2.7
40-45	2.7	0.0	0.0	0.0	0.0	0.0	0.0	2.7
45-50	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4
50-55	1.5	0.0	0.0	0.2	0.0	0.2	0.0	1.9
55-60	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9
60-65	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	29.1	37.1	0.0	0.2	0.0	22.3	0.0	
							Grand Total	88.7

Figures 17 and 18. 1825 and current diameter distributions, **Huckleberry Lake**

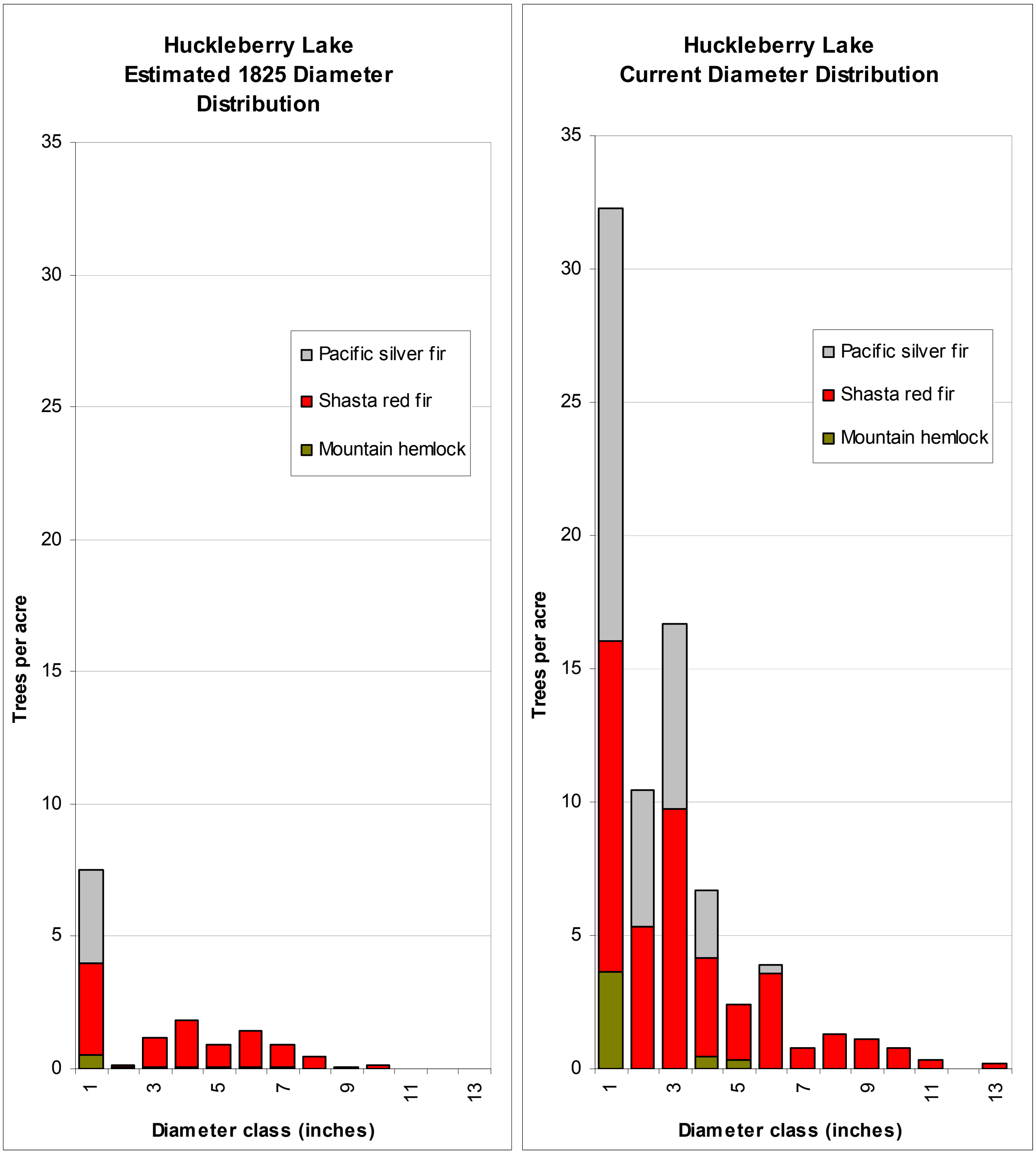


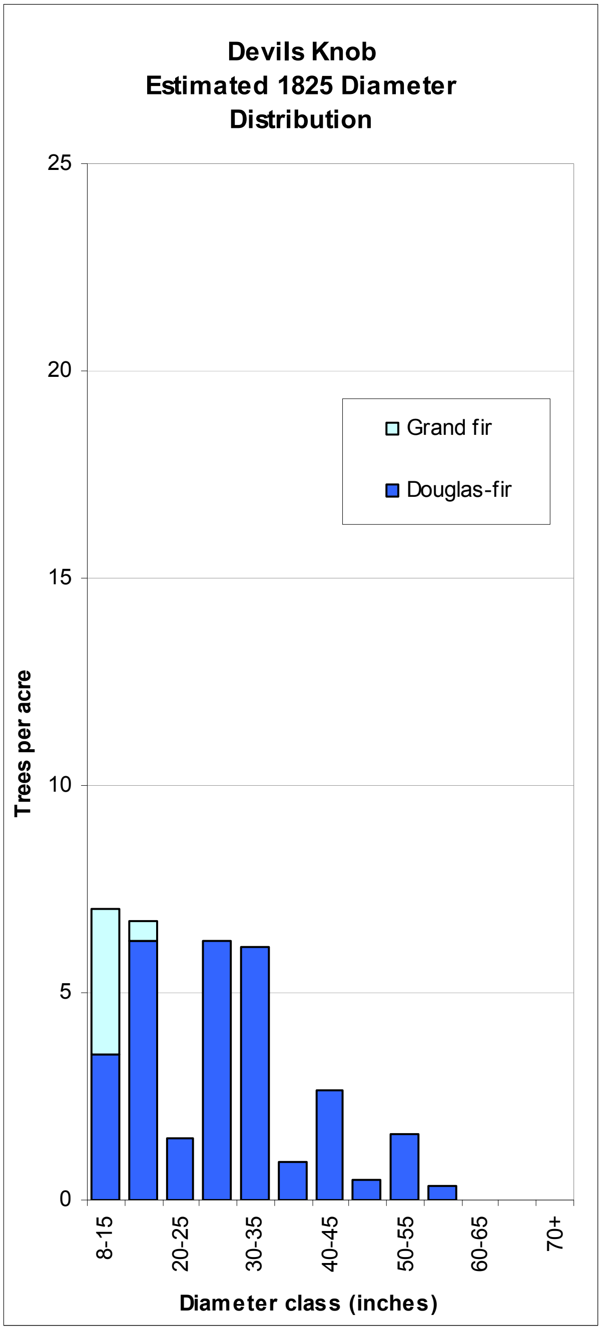
Table 18. Estimated trees per acre in 1825, by species, **Huckleberry Lake**

dbh (in.)	Shasta red fir	Pacific silver fir	sugar pine	ponderosa pine	mountain hemlock	incense cedar	white/black oak	Totals by DBH class
8-15	3.5	3.5	0.0	0.0	0.5	0.0	0.0	7.5
15-20	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.2
20-25	1.1	0.0	0.0	0.0	0.1	0.0	0.0	1.2
25-30	1.7	0.0	0.0	0.0	0.1	0.0	0.0	1.8
30-35	0.9	0.0	0.0	0.0	0.1	0.0	0.0	0.9
35-40'	1.4	0.0	0.0	0.0	0.1	0.0	0.0	1.4
40-45	0.8	0.0	0.0	0.0	0.1	0.0	0.0	0.9
45-50	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4
50-55	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
55-60	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	10.1	3.6	0.0	0.0	0.8	0.0	0.0	
							Grand Total	14.5

Table 19. Current trees per acre by species, **Huckleberry Lake**

dbh (in.)	Shasta red fir	Pacific silver fir	sugar pine	ponderosa pine	mountain hemlock	incense cedar	white/black oak	Totals by DBH class
8-15	12.3	16.3	0.0	0.0	3.7	0.0	0.0	32.3
15-20	5.3	5.1	0.0	0.0	0.0	0.0	0.0	10.5
20-25	9.7	7.0	0.0	0.0	0.0	0.0	0.0	16.7
25-30	3.7	2.5	0.0	0.0	0.4	0.0	0.0	6.7
30-35	2.1	0.0	0.0	0.0	0.3	0.0	0.0	2.4
35-40'	3.6	0.3	0.0	0.0	0.0	0.0	0.0	3.9
40-45	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.8
45-50	1.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3
50-55	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1
55-60	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.8
60-65	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Totals by sp.	41.2	31.2	0.0	0.0	4.4	0.0	0.0	
							Grand Total	76.9

Figures 19 and 20. 1825 and current diameter distributions, **Devils Knob**



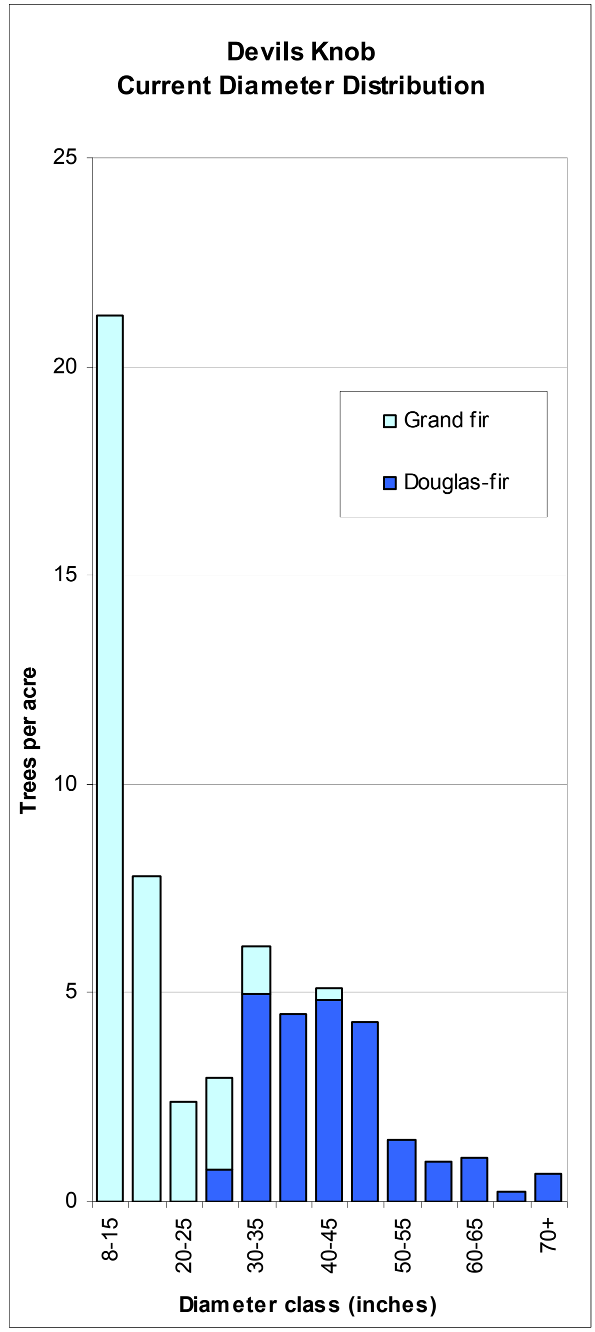


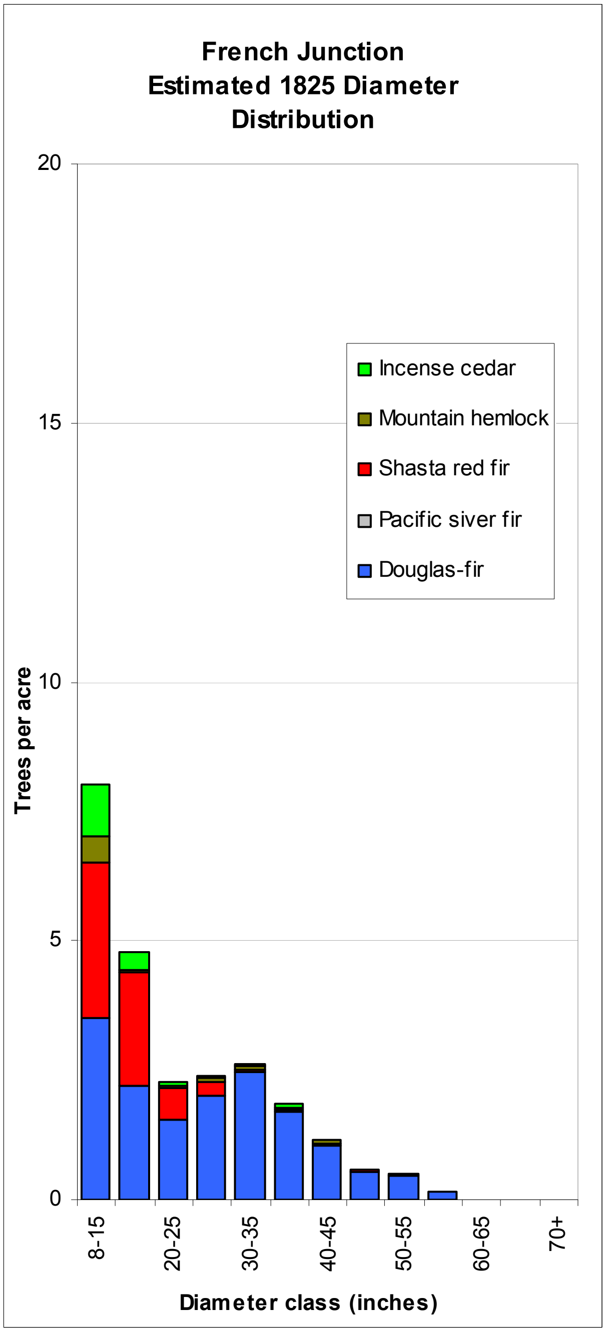
Table 20. Estimated trees per acre in 1825, by species, **Devils Knob**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	mountain hemlock	incense cedar	white/black oak	Totals by DBH class
8-15	3.5	3.5	0.0	0.0	0.0	0.0	0.0	7.0
15-20	6.2	0.5	0.0	0.0	0.0	0.0	0.0	6.7
20-25	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5
25-30	6.3	0.0	0.0	0.0	0.0	0.0	0.0	6.3
30-35	6.1	0.0	0.0	0.0	0.0	0.0	0.0	6.1
35-40'	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9
40-45	2.6	0.0	0.0	0.0	0.0	0.0	0.0	2.6
45-50	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5
50-55	1.6	0.0	0.0	0.0	0.0	0.0	0.0	1.6
55-60	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	29.6	4.0	0.0	0.0	0.0	0.0	0.0	
							Grand Total	33.6

Table 21. Current trees per acre by species, **Devils Knob**

dbh (in.)	Douglas-fir	grand fir	sugar pine	ponderosa pine	mountain hemlock	incense cedar	white/black oak	Totals by DBH class
8-15	0.0	21.2	0.0	0.0	0.0	0.0	0.0	21.2
15-20	0.0	7.8	0.0	0.0	0.0	0.0	0.0	7.8
20-25	0.0	2.4	0.0	0.0	0.0	0.0	0.0	2.4
25-30	0.8	2.2	0.0	0.0	0.0	0.0	0.0	2.9
30-35	5.0	1.2	0.0	0.0	0.0	0.0	0.0	6.1
35-40'	4.5	0.0	0.0	0.0	0.0	0.0	0.0	4.5
40-45	4.8	0.3	0.0	0.0	0.0	0.0	0.0	5.1
45-50	4.3	0.0	0.0	0.0	0.0	0.0	0.0	4.3
50-55	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5
55-60	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
60-65	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1
65-70	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
70+	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Totals by sp.	23.8	35.0	0.0	0.0	0.0	0.0	0.0	
							Grand Total	58.8

Figures 21 and 22. 1825 and current diameter distributions, **French Junction**



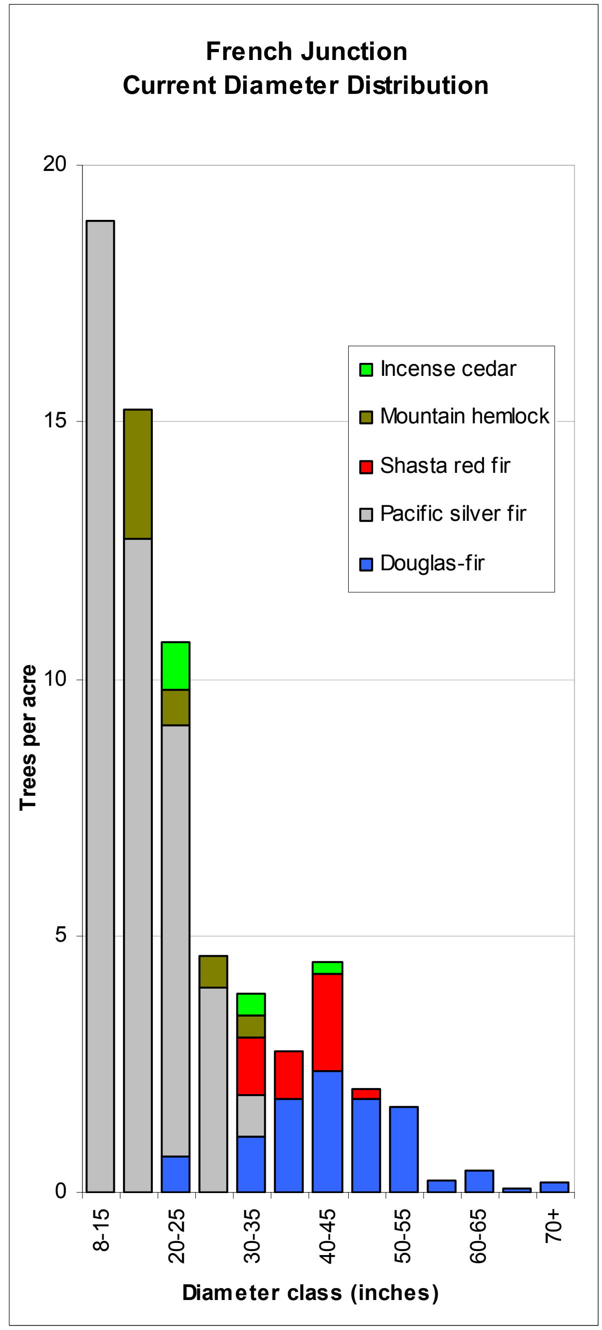


Table 22. Estimated trees per acre in 1825, by species, **French Junction**

dbh (in.)	Douglas-fir	Pacific silver fir	Shasta red fir	ponderosa pine	mountain hemlock	incense cedar	white/black oak	Totals by DBH class
8-15	3.5	0.0	3.0	0.0	0.5	1.0	0.0	8.0
15-20	2.2	0.0	2.2	0.0	0.1	0.3	0.0	4.8
20-25	1.5	0.0	0.6	0.0	0.1	0.1	0.0	2.3
25-30	2.0	0.0	0.3	0.0	0.1	0.1	0.0	2.4
30-35	2.5	0.0	0.1	0.0	0.1	0.1	0.0	2.6
35-40'	1.7	0.0	0.1	0.0	0.1	0.1	0.0	1.8
40-45	1.0	0.0	0.1	0.0	0.1	0.0	0.0	1.1
45-50	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.6
50-55	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.5
55-60	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
60-65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals by sp.	15.6	0.0	6.3	0.0	0.8	1.5	0.0	
							Grand Total	24.3

Table 23. Current trees per acre by species, **French Junction**

dbh (in.)	Douglas-fir	Pacific silver fir	Shasta red fir	ponderosa pine	mountain hemlock	incense cedar	white/black oak	Totals by DBH class
8-15	0.0	18.9	0.0	0.0	0.0	0.0	0.0	18.9
15-20	0.0	12.7	0.0	0.0	2.5	0.0	0.0	15.3
20-25	0.7	8.4	0.0	0.0	0.7	0.9	0.0	10.7
25-30	0.0	4.0	0.0	0.0	0.6	0.0	0.0	4.6
30-35	1.1	0.8	1.1	0.0	0.5	0.4	0.0	3.9
35-40'	1.8	0.0	0.9	0.0	0.0	0.0	0.0	2.7
40-45	2.4	0.0	1.9	0.0	0.0	0.2	0.0	4.5
45-50	1.8	0.0	0.2	0.0	0.0	0.0	0.0	2.0
50-55	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1.7
55-60	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
60-65	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4
65-70	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
70+	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Totals by sp.	10.4	44.9	4.1	0.0	4.3	1.6	0.0	
							Grand Total	65.2