HISTORICAL SAVANNA STRUCTURE AND SUCCESSION AT JIM'S CREEK, WILLAMETTE NATIONAL FOREST, OREGON

by

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A THESIS

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"Historical Savanna Structure and Succession at Jim's Creek, Willamette National Forest, Oregon," a thesis prepared by Jonathan William Day in partial fulfillment of the requirements for the Master of Science degree in the Department of Geography. This thesis has been approved and accepted by:

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An Abstract of the Thesis of

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Title: HISTORICAL SAVANNA STRUCTURE AND SUCCESSION AT JIM'S CREEK, WILLAMETTE NATIONAL FOREST, OREGON

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Dr. Patrick Bartlein

Oak savanna was once a major ecosystem of Oregon's Willamette Valley. Changing land-use patterns, urbanization and fire suppression have contributed to the loss of oak savanna throughout its former range, and it is estimated that less than 1% remains. Using tree distribution, tree-age and environmental data, historical savanna structure and recent forest succession at Jim's Creek, Willamette National Forest were investigated. Data were collected at 38 30 m x 30 m study plots representing five different community types. Monte Carlo methods were utilized to simulate community-wide tree age class and species distributions. Results indicate that the area was once an open savanna with 17 trees/ha composed of Oregon white oak, ponderosa pine and Douglas-fir. Beginning 125-150 years ago, dramatic changes took place and the area is now principally a Douglas-fir forest with up to 566 trees/ha. Oak comprised 35% of former savanna trees, but only 2% of current trees.

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CHAPTER I

INTRODUCTION

Oak savanna was once a major ecosystem within Oregon's Willamette Valley and surrounding foothills (Habeck 1962; Thilenius 1968; Johannessen et al. 1971). At the time of Euro-American settlement (circa 1850) oak savanna occupied over 213 000 ha within the Willamette Valley (Hulse et al. 2002). Typical plant community structure consisted of widely spaced Oregon white oak (*Quercus garryana)* within an upland prairie dominated by native grasses and forbs. Throughout the Pacific Northwest, savanna is generally understood to contain widely spaced trees at densities of less than 50 trees/ha (Agee 1993). Frequent disturbance by fire was necessary to maintain the low tree density and open canopy structure (Agee 1993). Changing land-use patterns, urbanization and fire suppression have contributed to the loss of oak savanna throughout its former range, and it is estimated that less than 1% remains in Oregon (Noss et al. 1995; Hulse et al. 2002).

Oregon white oak distribution extends from Vancouver Island, British Columbia to Los Angeles County, California, spanning more than 15° of latitude (Figure 1). Its best development occurs in western Oregon and Washington within the Cowlitz, Lewis and Willamette River basins, where it attains heights of 15-27 m and diameters of 60-100 cm.

Mature individuals may attain diameters greater than 200 cm and heights in excess of 35 m (Burns and Honkala 1990).

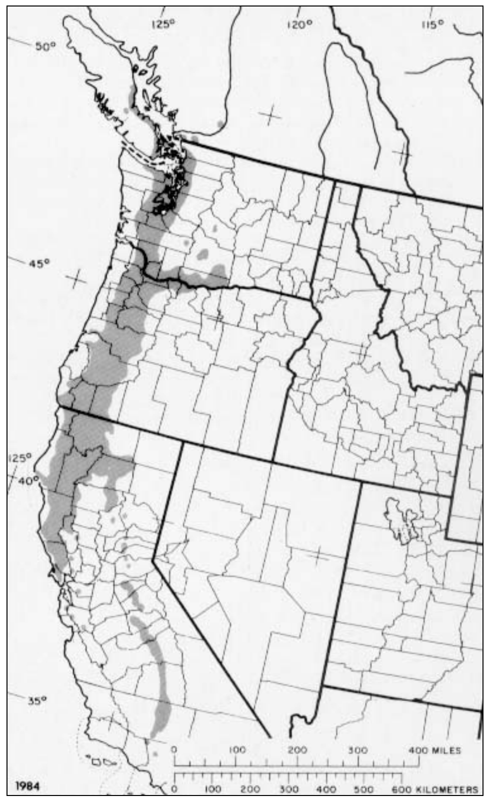

Figure 1 - *Quercus garryana* range (from Burns and Honkala 1990).

Despite its former prominence and current conservation importance, there are no published studies on the detailed structure of pre-settlement *Quercus garryana* savanna and very limited information on its successional dynamics since Euro-American settlement. Historical forest and savanna structure have been reconstructed for a number of sites in western North American, although none have looked specifically at *Q. garryana* savanna (e.g., Cole 1977; Mast et al. 1999; Parish et al. 1999; Ohlson and

Schellhaas 2000). Thilenius' (1968) work in closed canopy *Q. garryana* woodlands found that most trees established around 1862, although he noted larger, savanna-form oaks were scattered through the woodlands that likely predated the other trees. It is believed that, in the absence of disturbance, *Q. garryana* savanna eventually succeeds to forest, likely coniferous, within the Willamette Valley (Johannessen et al. 1971; Franklin and Dyrness 1988), although there are few definitive studies.

There are numerous efforts underway in the Pacific Northwest to create or restore oak savanna habitat for increased biodiversity, and in some cases, as a method of fuels management. Such efforts could benefit from an understanding of historical oak savanna structure and the changes that have occurred to produce current landscapes. Information on the former is useful for defining potential restoration goals for this imperiled ecosystem, and information on the latter is necessary to devise practical management strategies to achieve and maintain savanna conditions over time. To this end, I posed two questions. First, what was the historical age structure and species composition of an oak savanna in Oregon? Second, what have been the temporal and compositional patterns of succession since Euro-American settlement, approximately 150 years ago? By answering these two questions, a dynamic picture of savanna structure and development can be created, informing future management and restoration efforts at former oak savanna sites throughout the Pacific Northwest.

CHAPTER II

STUDY AREA

Jim's Creek (122°25'W, 43°30'N) is a 276 ha area within the Willamette National Forest in Oregon's western Cascades (Figure 2) that has been identified by the US Forest Service for restoration to pre-Euro-American settlement conditions. The site is within the upper Middle Fork Willamette River valley and occupies a predominantly south-southwest facing slope with elevations ranging from 600 m to 1000 m above sea level. Average precipitation at Oakridge, approximately 25 km north of Jim's Creek, is 116 cm annually, with 75% falling between November and April. Fires are a frequent occurrence due to lightning strikes during the spring and summer months, with seven ignitions having occurred within the site since 1970 (T. Bailey, personal communication, 2005).

Other than a 25 ha ponderosa pine plantation, the site has experienced little direct disturbance due to logging or other factors, and is currently a mosaic of coniferous forest and open meadows. A number of large Oregon white oak, ponderosa pine (*Pinus ponderosa*), incense-cedar (*Calocedrus decurrens*) and Douglas-fir (*Pseudotsuga menziesii*) dating from before Euro-American settlement (circa 1850) are scattered throughout the stand. There are also small numbers of sugar pine (*Pinus lambertiana*) and grand fir (*Abies grandis*). It has been hypothesized that Jim's Creek was once an open savanna with widely spaced ponderosa pine, Douglas-fir and oak that developed in the presence of high frequency, low-intensity fires of both natural and Native American origin (Winkler and Bailey 2002). Beginning with the suppression of Native American burning, and later with broad-scale fire suppression, the openings and meadows of the area have become increasingly crowded with younger trees. Large oaks are becoming increasingly rare as they are out-competed by conifers, and many appear to be in severe decline. The site is now dominated by Douglas-fir, with oaks principally restricted to the edge of meadows (Winkler and Bailey 2002). Thus, in many ways Jim's Creek appears to reflect proposed successional dynamics in oak savanna in the Willamette Valley and surrounding foothills (Johannessen et al. 1971; Franklin and Dyrness 1988) and is one of few former oak savanna sites that has not experienced at least some selective logging of larger trees.

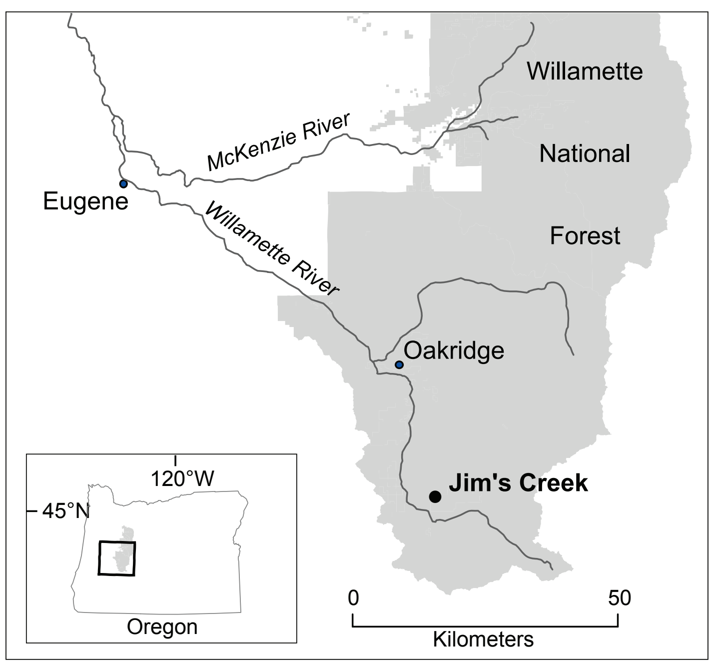

Figure 2 – Location of Jim's Creek.

CHAPTER III

METHODS

Five stratified random 30 m belt transects ranging from 240 m to 660 m in length were laid out across Jim's Creek for a total of 3180 m of transect length. The transects were oriented north-south to run primarily up and down slopes from the Middle Fork Willamette River along the southern boundary to the ridgeline on the northern boundary. Two transects were truncated before they ran into a plantation and/or began to closely parallel a road. Plant community type was assessed every 60 m along each transect to determine relative frequencies across the site (Table 1). These frequencies were then verified with GIS analysis and aerial photos to confirm they reflected actual site-wide community frequencies. Within the belt transects, 31 plots were selected for further study based on community type. Each plot was 30 m by 30 m and located at the center of a 60 m segment along the belt transect. An additional seven plots were selected outside of the belt transects to sufficiently represent the community type occupying the transition from meadow to forest or woodland (Figure 3). Slope, aspect, percentage of exposed rock, percentage of surface rock, elevation and canopy cover data were collected at each study plot. Aspect was determined in the field using a compass, while slope was calculated along the aspect using a clinometer and averaging the up-slope and down-slope measurements. Percentage of exposed rock (emerging from below the ground surface and potentially bedrock) and surface rock (resting on or near the top of the soil surface) were quantified by ocular estimation in the field. Canopy cover was calculated from the center of each study plot using a spherical densiometer (Lemmon 1956). Elevation was determined via GIS, using a digital elevation model and GPS points taken from the center of each study plot.

Table 1 – Community types and study plots.

Community Type	Percentage of total transect	Total study plots	Total study plot area (m^2)	Method of Determination
Forest	47.54%	16	14 400	Plot Canopy Cover ≥ 60%
Woodland	26.23%	7	6300	25% ≤ Plot Canopy Cover < 60%
Transition	3.28%	7	6300	Edge of plot located 15 m from meadow edge
Meadow - North Edge	9.84%	5	4500	Located on north edge of meadow
Meadow - South Edge	6.56%	3	2700	Located on south edge of meadow
Meadow	6.56%	0	0	Located in meadow

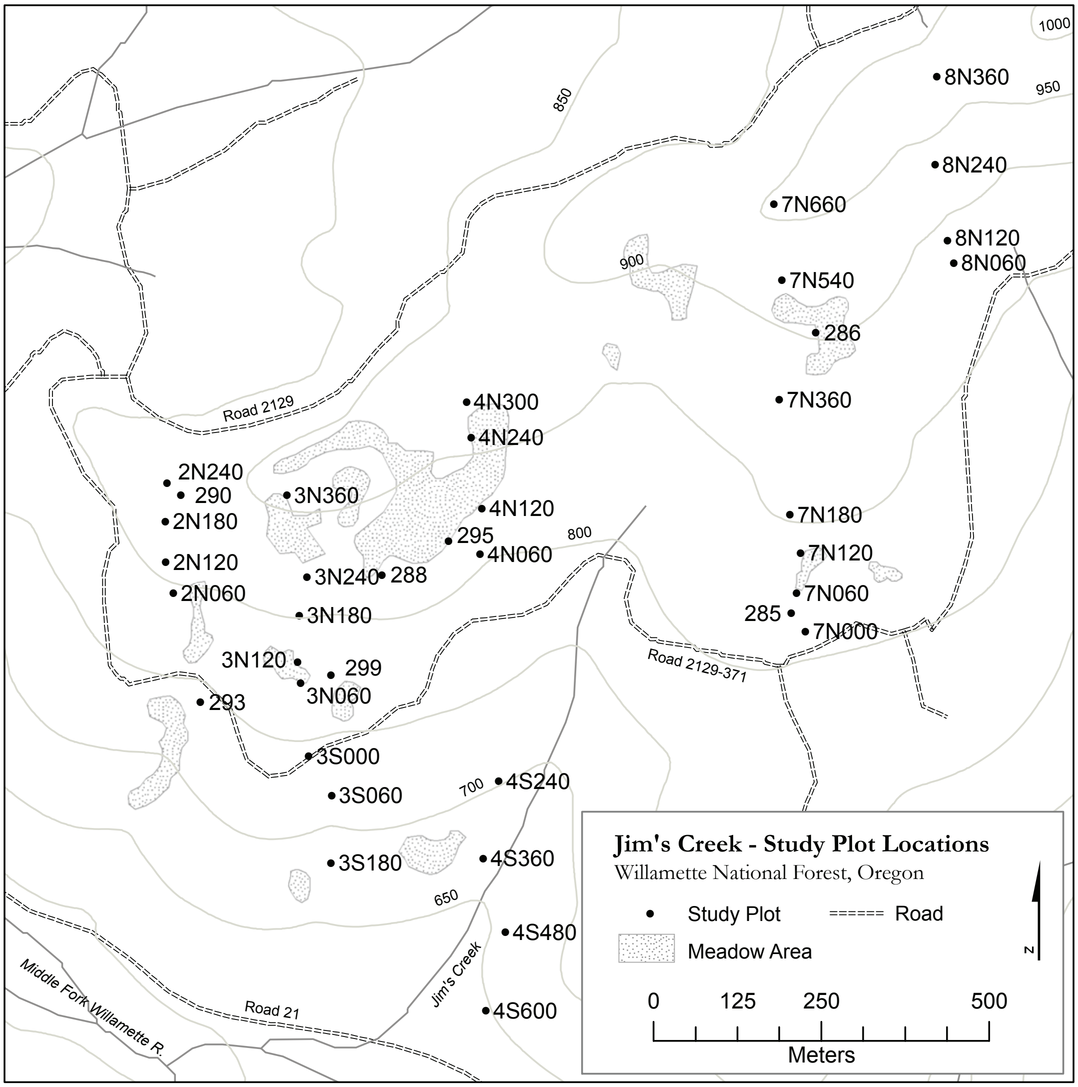

Figure 3 – Location of study plots at Jim's Creek. Selected plots were identified along the transects to represent the diversity of current and historic site conditions. An additional seven plots were selected outside the belt transects to sufficiently represent the community type occupying the transition from meadow to forest or woodland. Transect plots are indicated with a five letter code indicating transect number and direction (e.g., 3N) and distance along the transect (e.g., 120). Transition plots are indicated with a number between 285 and 299.

Meadow areas were not sampled or included in further analysis of historical tree distribution or successional trajectories except to adjust calculations of site-scale tree densities, as they by definition had no trees to sample. Meadows currently comprise approximately 7% of the Jim's Creek site.

To gather data on successional trajectories that have characterized the site since Euro-American settlement, the 38 study plots were sampled for tree distribution by species and size class. All trees within each plot were tallied and placed into one of five size classes based on diameter at breast height (dbh): 0-25 cm, 25-50 cm, 50-75 cm, 75-100 cm and over 100 cm. A sapling was placed into the 0-25 cm category if it was over 70 cm tall. Within each plot, two trees in each of the 0-25 cm, 25-50 cm and 50-75 cm size classes were cored to determine their ages. All trees over 75 cm dbh were cored, as well as a selection of oaks. Tree age was determined using standard dendrochronology techniques (Stokes and Smiley 1968; Phipps 1985). The increment borer was operated both by hand as well as with the assistance of a powered drill. A total of 298 trees were successfully cored and aged within the study plots.

Approximately 50 conifers and 30 oaks outside of the study plots, but within the belt transects, were identified as possibly pre-dating Euro-American settlement based on size, bark structure and overall form. Forty-three of these trees were cored and aged, for a total of 341 aged trees included in this study. Although several large incense-cedars were found along the transects, none could be effectively dated due to internal rot. Also, because of rot and general difficulty in coring, only 20 oaks were successfully cored and aged.

Cores which missed the pith were corrected using an overlay of concentric circles to estimate distance and number of rings to the pith (Wong and Lertzman 2001). Several cores taken from very large trees did not come close enough to the pith to display arcing rings. For these, the length of the core was measured and compared with the total dbh of the tree. The innermost 5-10 rings were measured to determine the number of rings/cm and then multiplied by the amount of missing core based on the total dbh of the tree (Miller 1995).

Thirteen conifer saplings were destructively sampled to determine the age of trees at coring height (mean coring height = 55 cm). A regression equation of age as a function of height was developed based on the growth rates of these saplings and applied to each of the cored trees. Growth rates were found to be similar among conifer species, so only one equation was developed. One issue with this method is that current sapling growth rates may be different from those of older trees that established in more open conditions (Wong and Lertzman 2001). Due to their infrequent occurrence and importance on the site, no oak saplings were cut or included in the regression equation, but oak ages were still adjusted using the equation with the assumption that an oak would grow to coring height no faster than a conifer, and would likely take longer. Given these caveats, the ages of oaks may be slightly underestimated, while those of conifers may be slightly overestimated.

Simulation

To estimate tree age distributions within the plots and across the entire site without taking increment cores from every tree, it was necessary to develop a simulation of tree ages based on size-class distribution. Monte Carlo methods were used to develop age distributions for each community type based on tree tallies within each plot and tree ages derived from actual increment cores. Only Douglas-fir, ponderosa pine, incense-cedar and oak were used in the simulation (representing 99% of total tallied trees). Within the 38 study plots, 2104 trees were tallied and included in the simulation. The 341 trees that were cored and aged along the transects were used to develop a pool of potential ages for the tallied trees. The general algorithm for one run is described below:

1. Choose a community type
2. Select a plot that is within the community type
3. For every tree counted in the plot, randomly assign an age derived from an increment core that is the same species, within the same size class and from the same community type
4. Repeat for each plot and every community type

There were two exceptions to the above rules. First, ages for oak trees were assigned regardless of the community type the cored tree was from. This was done because so few could be effectively aged. Second, trees over 100 cm dbh were also assigned ages regardless of community type, since current community types most likely do not reflect the historical types these large, mostly pre-settlement trees were growing in. Saplings were randomly assigned ages from 5 to 15 years, based on the destructive sampling. The simulation was run 50 times for each study plot.

To develop community-level age distribution graphs and statistics, the output from the simulation was weighted across study plots, taking into account the differing numbers of study plots within each community type (Table 1), as well as the total number of simulation runs (50). Statistics for all simulation-derived community-level data were calculated from actual output values for each study plot and did not need to be normalized.

The R statistics package was used to develop the simulation and for all subsequent statistical analyses (R Development Core Team 2005).

Regression

Multiple regression analysis was performed to explore possible relationships between environmental variables at the plot level and tree growth rates. Heat load and direct incident radiation were computed from slope, aspect and elevation for each plot using equation 3 from McCune and Keon (2002). Canopy cover, percentage of exposed rock, percentage of surface rock, density and basal area were also used in the regression. In an attempt to isolate the effects of competition from nearby trees, an adjusted plot basal area was computed, where the basal area of the individual tree was subtracted from the total plot basal area.

A two-way analysis of variance (ANOVA) was also performed to investigate differences in growth rates between species and communities, and any interactions between the two.

Issues

Reconstructing the history of an area based on dendrochronological evidence is not an exact method. By its very nature, the record of tree establishment and death is disappearing as time passes, erased by processes of decay and disturbances such as fire. At Jim's Creek, fire is presumed to be a major influence on stand and savanna structure, with many of the trees having fire scars and charred bark. In addition, there is no way of knowing how many saplings and small trees died in the past.

This study focused solely on living trees as a record of prior structure and composition, thus any standing snags or downed logs were not taken into account. Although there are significant numbers of snags and logs that could change estimates of presettlement tree densities, it is difficult to age them precisely or determine when they died. Decomposition rates are likely low in this area (Edmonds 1990) and a large (>100 cm) downed tree may have been lying on the forest floor for hundreds of years in the absence of a severe fire, further complicating matters. Since this study focused only on living trees, this inevitably leads to underestimation of pre-Euro-American settlement tree density.

CHAPTER IV

RESULTS

Age and dbh regressions based on cored trees for Douglas-fir (R^2=0.46), ponderosa pine (R^2=0.63) and oak (R^2=0.59) indicate significant relationships between age and dbh (Figure 4). No significant relationship was found for incense-cedar.

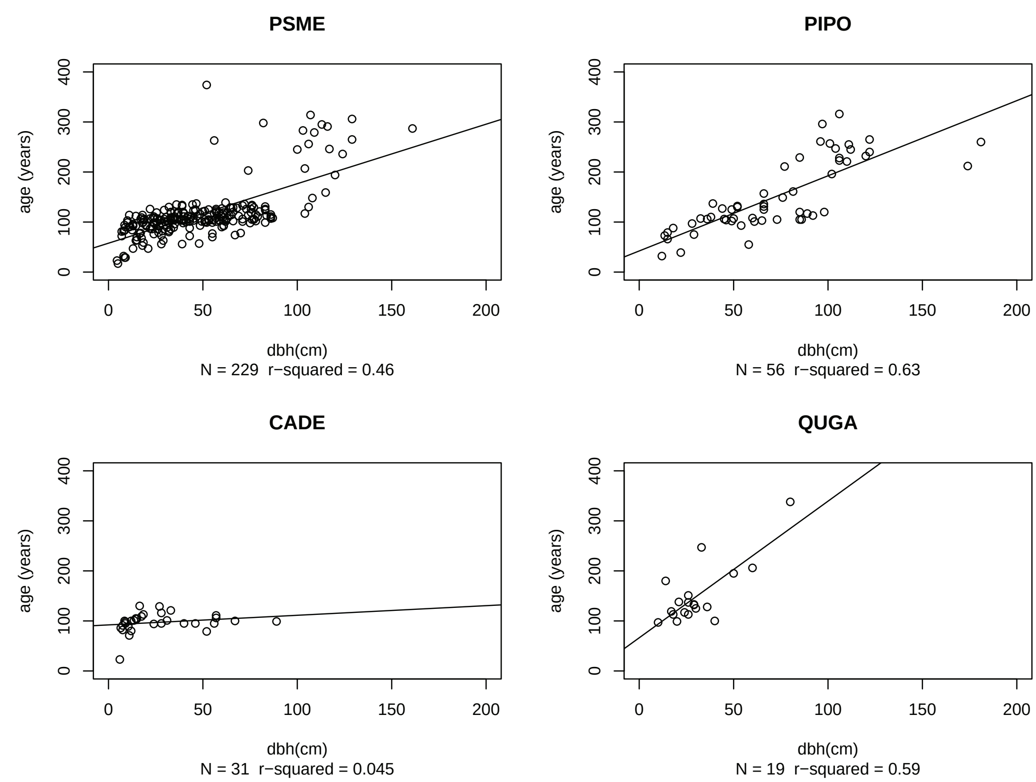

Figure 4 – Age and dbh of cored trees with regression lines.

Table 2 – Age statistics for community types based on simulation results.

Community	mean	Sd	Median	skew
Forest				
PSME	93.89	42.04	103	1.58
PIPO	96.13	83.18	107	0.60
CADE	85.44	35.82	100	-1.27
QUGA	150.82	58.31	132	1.80
Overall	93.36	44.36	100	1.31
Woodland				
PSME	101.94	23.19	104	2.37
PIPO	196.79	73.61	223	-0.77
CADE	95.64	10.70	98	-0.92
QUGA	151.75	59.93	132	1.82
Overall	102.34	26.81	101	3.25
Transition				
PSME	85.64	36.11	92	-0.75
PIPO	97.28	46.36	104	1.44
CADE	92.33	35.98	95	-1.13
QUGA	151.50	59.01	132	1.87
Overall	98.15	48.09	99	1.16
Meadow - South Edge				
PSME	40.01	35.19	17	0.78
PIPO	37.22	45.00	12	1.09
CADE	29.25	25.15	14	0.96
QUGA	149.88	58.63	132	1.75
Overall	47.58	48.86	17	1.80
Meadow - North Edge				
PSME	84.53	33.32	99	-1.33
PIPO	67.46	49.62	75	0.72
CADE	10.87	4.96	11	0.42
QUGA	151.01	58.83	132	1.74
Overall	89.38	55.56	99	1.00

Based on simulation results, community types display age distributions that are significantly different from each other (Kolmorogov-Smirnov test, $p < 0.001$ for all plot combinations). Mean age (Table 2) was lowest in the south meadow edge plots ($\bar{x} = 48$, sd = 49) and highest in woodlands ($\bar{x}$ = 102, sd = 27). All community age distributions displayed positive skew, indicating most of the trees are young and located on the lower end of the distribution (Table 2). The mean site-level tree age (Table 3) was 102 years (sd = 45), with incense-cedar being the youngest ($\bar{x}$ = 72, sd = 23) and oak being oldest ($\bar{x}$ = 141, sd = 55) (Table 3). Mean dbh across the site was 27 cm (Table 3).

Table 3 – Site-level statistics for age and dbh based on simulation results. Values are weighted based upon total percentage each community type occupies along the transect (see Table 1).

Category	mean	Sd	median	skew
Age (years)				
PSME	85.12	32.84	90	1.27
PIPO	109.59	68.20	121	0.27
CADE	71.72	23.15	78	-0.78
QUGA	141.16	55.01	123	1.68
Overall	101.90	44.80	103	0.61
DBH (cm)				
PSME	28.35	20.15	24	1.00
PIPO	35.25	35.63	22	1.18
CADE	18.88	15.69	13.5	1.48
QUGA	20.74	9.11	20	1.51
Overall	27.17	21.44	22	1.37

A two-way ANOVA was performed to test for differences in growth rate between species and community type (Table 4). Growth rates were found to be significantly different between species ($p < 0.001$), but did not differ among community types ($p = 0.1751$). No interaction was found between the two. Ponderosa pine displayed the highest mean growth rate (0.49 cm/year), followed by Douglas-fir (0.42 cm/year), incense-cedar (0.28 cm/year) and oak (0.21 cm/year) (Figure 5).

Table 4 – Growth rate ANOVA results.

Sources of Variance	Degrees of Freedom	Sum of Squares	Mean Squares	F-Statistic	P-Value
Community Type	4	0.2291	0.0573	1.5961	0.1751
Species	5	1.7452	0.3490	9.7268	< 0.001 ***
Interaction	12	0.1309	0.0109	0.3041	0.9885
Residuals	319	11.4468	0.0359		

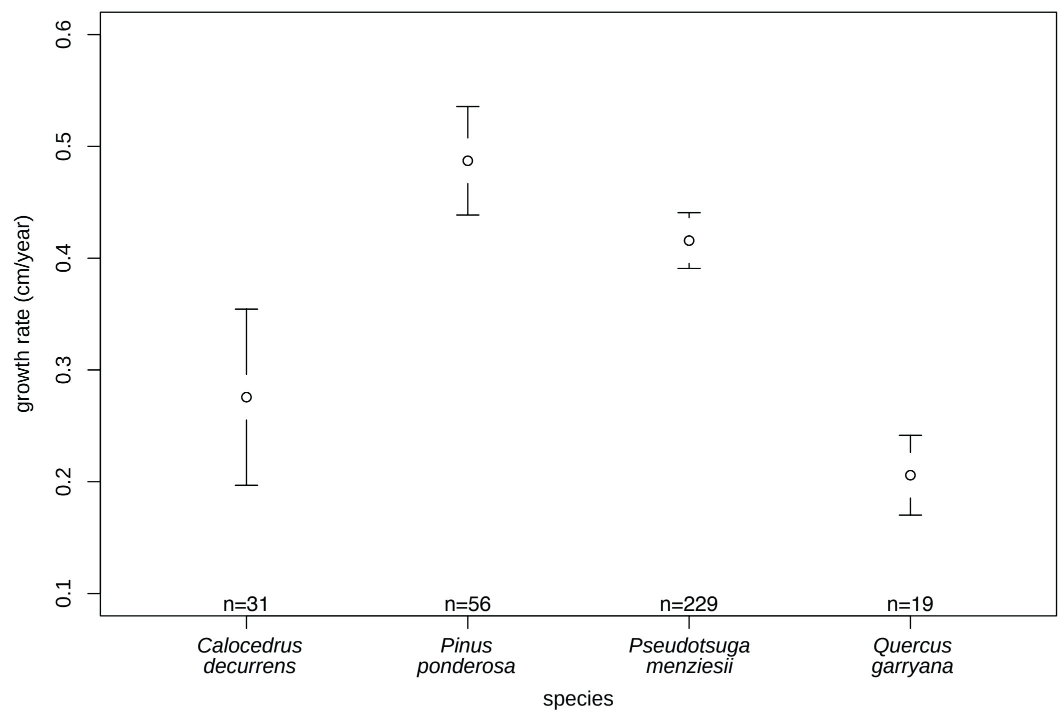

Figure 5 – Species growth rates across the site. Error bars indicate 95% confidence interval.

The multiple regression analysis used heat load, direct incident radiation, canopy cover, percentage of exposed rock, percentage of surface rock, tree density and adjusted basal area as variables to help possibly explain and predict tree growth rates found across the site. Results from the regression indicate that none of the variables were predictive of growth rate, and poor adjusted R^2 values characterized each of the attempted models.

For purposes of brevity, living trees less than 150 years old will be referred to as “post-settlement” trees and those older than 150 years will be referred to as “pre-settlement” trees, with the understanding that settlement in this case refers to European-American settlement, which occurred beginning around 1850.

All community types have higher densities of post-settlement trees as compared to pre-settlement trees (Table 5 and Figure 6). The north meadow edges display the smallest densities of post-settlement trees (309 trees/ha), while south meadow edges and forests have the greatest (799 trees/ha and 685 trees/ha, respectively) (Table 5). When weighting each community type based on the total percentage each constitutes along the transect (Table 1), there is an overall 3325% difference in post-settlement versus pre-settlement tree density across the site, with 581 post-settlement trees/ha and 17 pre-settlement trees/ha (Table 5 and Figure 6).

Table 5 - Tree densities among community types. Overall values are weighted based upon total percentage each community type occupies along the transect (see Table 1). Note that post-settlement trees are those living which are presently <= 150 years old, while pre-settlement trees are those living trees which are >150 years old. This table does not imply historical tree densities.

Community	Total Density (trees/ha)	Living Post-Settlement Tree Density (trees/ha)	Living Pre-Settlement Tree Density (trees/ha)
Forest	703.47	685.26	18.21
PSME	554.17	542.64	11.53
PIPO	27.78	23.36	4.42
QUGA	14.58	12.32	2.26
Woodland	593.65	581.40	12.25
PSME	422.22	418.76	3.46
PIPO	9.52	2.70	6.83
QUGA	6.35	4.38	1.97
Transition	633.33	597.05	36.29
PSME	409.52	408.38	1.14
PIPO	55.56	52.38	3.17
QUGA	103.17	71.21	31.97
Meadow - South Edge	818.52	799.11	19.41
PSME	533.33	533.33	0.00
PIPO	103.70	103.70	0.00
QUGA	59.26	39.85	19.41
Meadow - North Edge	335.56	308.98	26.58
PSME	155.56	155.56	0.00
PIPO	91.11	85.29	5.82
QUGA	64.44	44.44	20.00
Overall	597.63	580.68	16.95

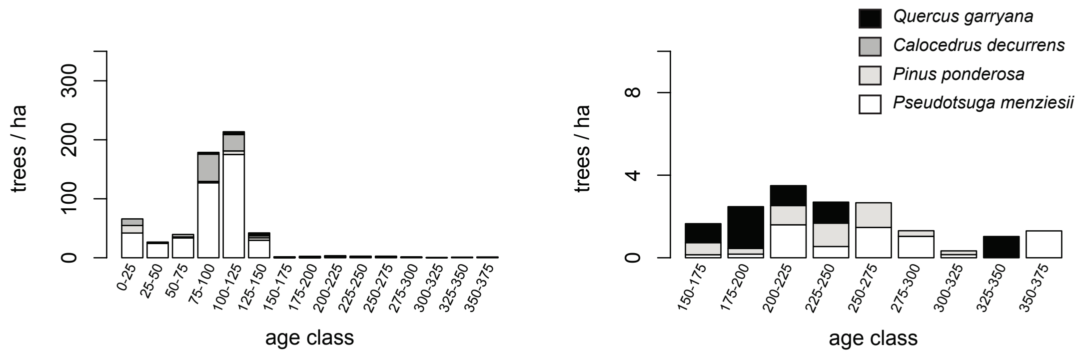

Figure 6 - Overall, site-wide age and species distribution after weighting based on frequency of community type found along transect (see Table 1). Figure on left shows entire 375 history. Figure on the right shows only 150-375 year old trees. Note difference in scales.

Historical Community Structure

A total of 46 trees along the belt transects and within the study plots were cored and found to pre-date Euro-American settlement. The oldest tree found was a 374-year-old Douglas-fir. Four other trees were found to be over 300 years old. The oldest trees occurred in the forest community, which was the only community to contain individuals from the 350-375 year old age class (Figure 7). Twenty oak trees were cored, six of which were found to pre-date settlement. However, based on dbh measurements, bark structure and overall form, it is almost certain that most of the large oaks found at the site also pre-date settlement.

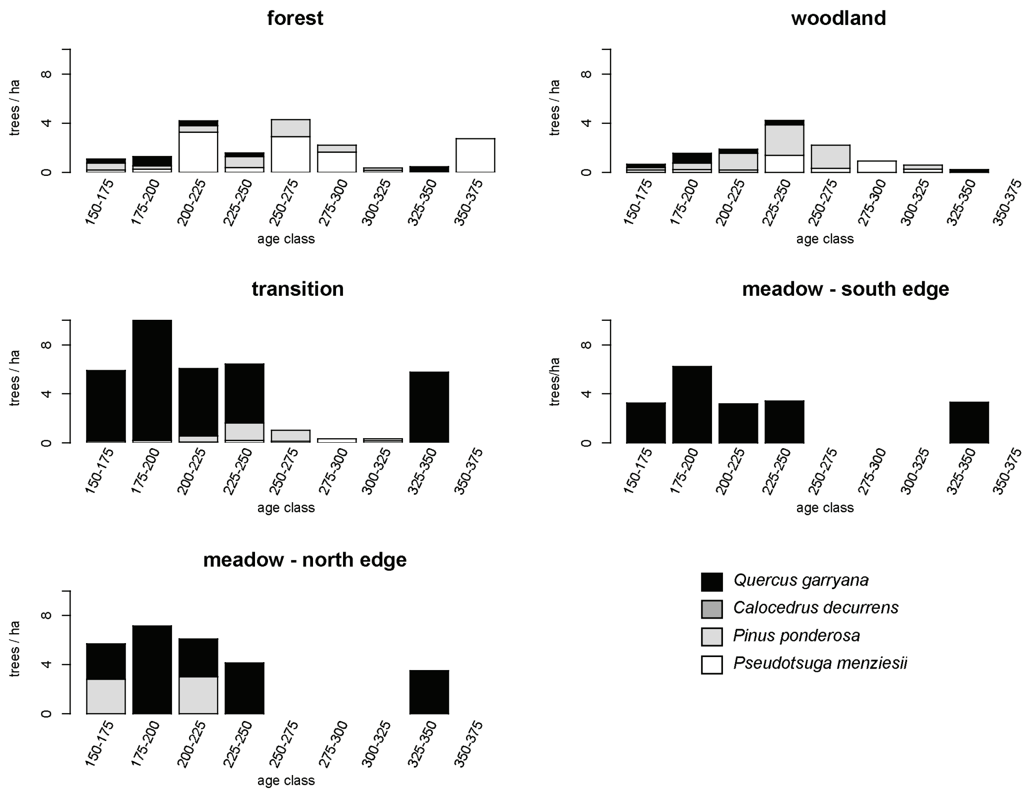

Figure 7 - Community age and species distributions 150-375 years ago based on simulation results.

Pre-settlement oaks were found in every community and were the only species with pre-settlement individuals found in south meadow edge communities (Figure 7). They appear to have been the most significant component of both meadow edge communities and the transition community. Pre-settlement Douglas-fir was relatively more common in the forest and woodland communities, but no individuals were found in either north or south edge meadow communities (Figure 7). Several large diameter (>100 cm) incense-cedars were cored, but due to internal rot, could not be effectively aged, and were too far from the pith to reliably estimate. However, a few were found to have a minimum age in excess of 200 years, and were likely older than 300 years given their size. Though a minor component of the forest, these older incense-cedars are not represented in the final results due to lack of data.

Of the 2104 trees tallied and used in the Monte Carlo simulation, 74 were assigned ages greater than 150 years old. Because some large-diameter trees within the study plots could not be effectively aged, the simulation assigned ages from similar sized individuals following the algorithm as outlined previously. This explains the difference between the number of trees older than 150 years that were actually cored (46) and those from the simulation (74).

Forest and woodland communities have individuals from every age class between 150 and 350 years old (Figure 7). In meadow edge plots, however, there are gaps in age class representation, with no individuals occurring that are 250-325 years old or older than 350. Densities in the meadow edges for each age class greater than 150 years never exceed more than eight trees/ha (Figure 7). Transition plots are similar to meadow edge plots, with slightly higher densities of pre-settlement trees and few individuals that are 250-325 years old. Site-level species distributions for pre-settlement trees are 38% Douglas-fir, 35% oak, and 27% ponderosa pine.

Recent Succession

All communities display significant numbers of 100-125 year old trees (Figure 8), likely representing an increase in recruitment, although it is unknown how many trees may have initiated and died before establishing. The highest densities of this age class occur in the forest and woodland communities. High densities (>200 trees/ha) of 75-100 year old trees are also seen in forest and woodland communities (Figure 8). Woodlands have essentially no trees that have established within the past 50 years, while forest plots show low levels of establishment, with a slight increase occurring within the past 25 years. Oaks less than 150 years old are not present in either community type.

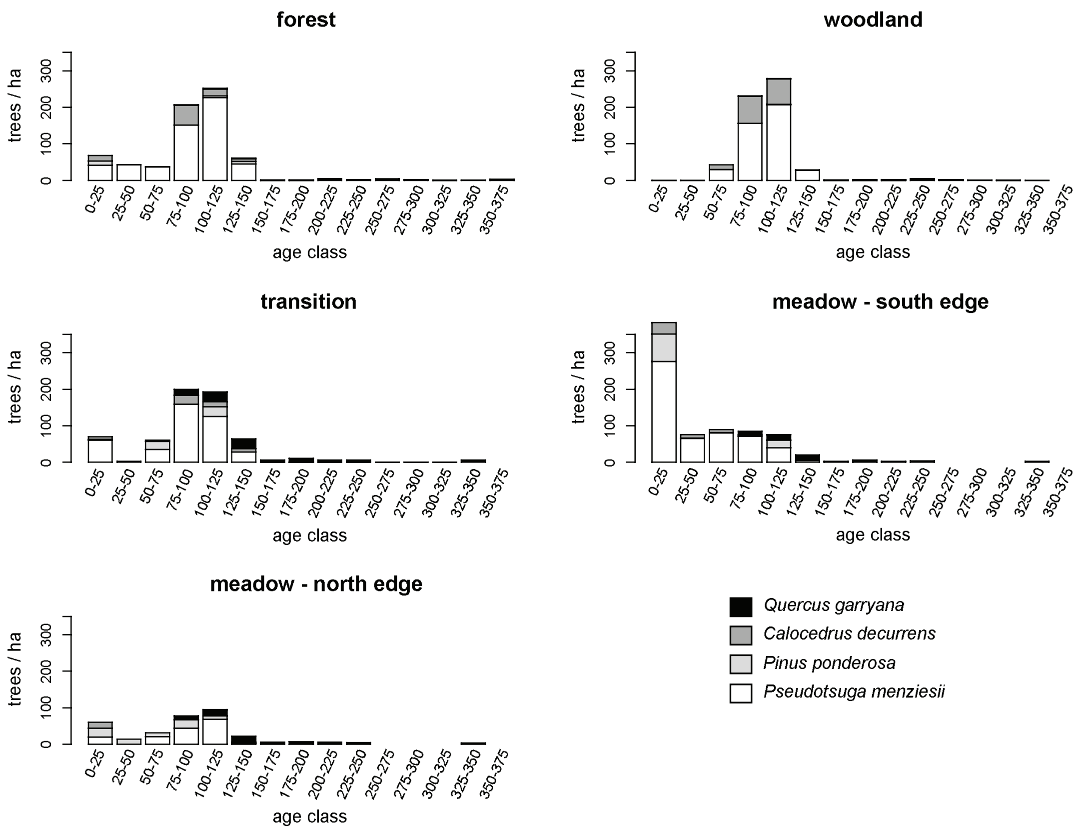

Figure 8 - Community age and species distributions based on simulation results. Note difference in scales between this figure and figure 7.

The transition plots are composed mainly of trees in the 75-100 year age class (30% of total trees) and 100-125 year age class (29% of total trees) (Figure 8). Oaks compose a significant part of transition communities, but there has been no establishment for the past 75 years. Instead, young Douglas-fir dominates the community, with most individuals being less than 125 years old. There are few trees in the 25-50 year age class, but, like other communities, there are several within the 0-25 year age class.

North meadow edges have the smallest post-settlement tree density of any community type (Figure 8 and Table 5). There are significant numbers of oaks in the 125-150 year age class, but, like other communities, there are none less than 75 years old. Likewise, there are no Douglas-fir trees older than 150 and most (44%) are within the 100-125 year age class. Recruitment of nearly equal numbers of Douglas-fir, ponderosa pine and incense-cedar has occurred over the past 25 years.

South meadow edges display the highest densities (> 300 trees/ha) of young trees (< 25 years), but the large cohort of 100-125 year old trees seen in other community types was not observed here. Instead, there is nearly even distribution of tree ages from 25-125 years old. Oaks are a significant part of the community, with individuals occurring in most age classes between 75-375 years. However, there are no oaks in the younger age classes (< 75 years). There is no Douglas-fir older than 125 years in any south meadow edge plot.

Species Changes

Figure 9 shows species age probability density functions from the Monte Carlo simulation across all community types. The probability density function can be considered a smoothed histogram represented by a continuous curve. For each species shown in figure 9, a curve showing the probability density function for each of the 50 model runs was drawn, effectively representing the different values that can occur within the model output. All species display a considerable increase in probability density centered around 100 years ago, indicating that the majority of trees across the site are near this age. Overall, 67% of trees across the site fall within the 75-125 year age classes. Oak is the only species that does not have live trees within the 0-25 year age class, and the youngest oaks across the site are in the 50-75 year old age class (Figure 8).

When taking into account the percentage of total area each community type occupies (based on Table 1), Douglas-fir currently comprises approximately 76% of total trees across all study plots, incense-cedar accounts for 16%, ponderosa pine for 5%, and oak accounts for only 2% (Figure 8).

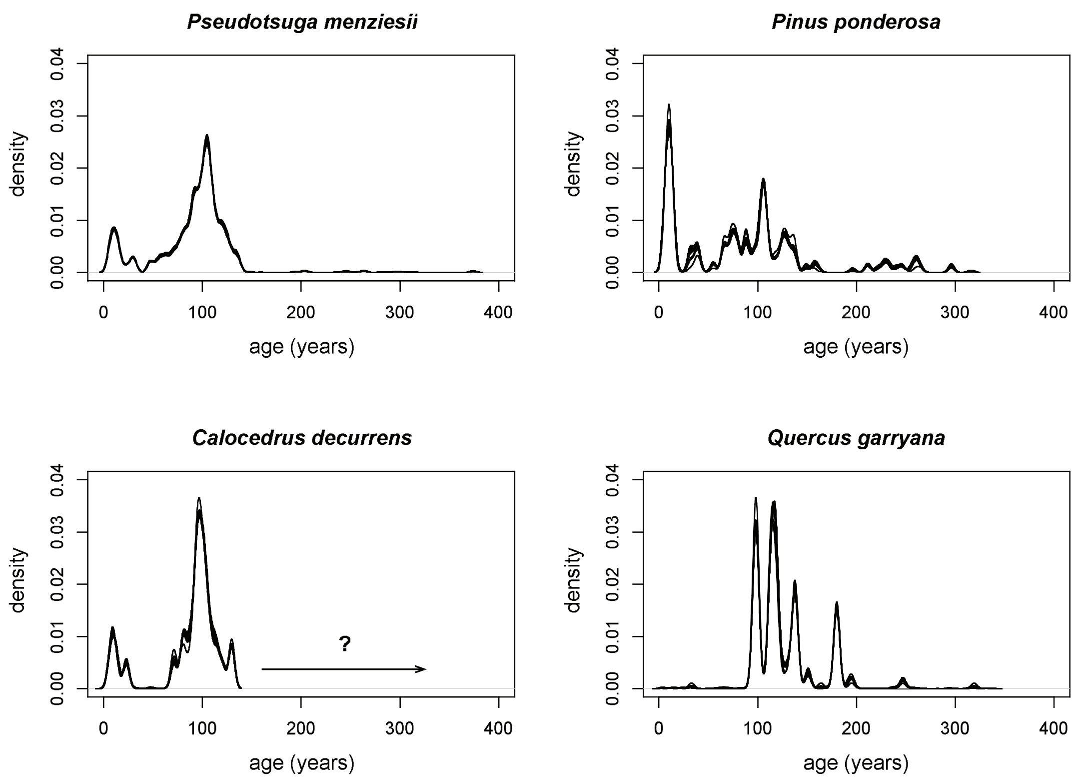

Figure 9 - Age class probability density function plots for each species. Lines show probability density function curves for each of the 50 model runs. Wider lines indicate greater variability in age frequencies from the simulation. The probability density function plot shown here is essentially a smoothed histogram, showing frequency of ages.

CHAPTER V

DISCUSSION

Pre-Settlement Conditions

My results support the assertion of Winkler and Bailey (2002) that Jim's Creek was historically a savanna, characterized by low tree densities. The area was dominated by Douglas-fir and Oregon white oak with lesser amounts of ponderosa pine.

Oregon white oak displays an open-grown form with low branches and wide crowns when growing in open conditions, where there is little to no competition for light (Burns and Honkala 1990). Half of the cored oak trees found to be older than 150 years at Jim's Creek displayed this open-grown canopy architecture, indicating they once grew in open conditions. Douglas-fir also displays an open-grown form, often referred to as a "wolf" tree with large, low, spreading limbs (Hadley and Savage 1996). Of the 24 Douglas-firs that were identified as pre-dating settlement, 19 (79%) of these displayed an open-grown form.

The low densities of pre-settlement trees (17 trees/ha) found across the site are consistent with the theory that Jim's Creek was a savanna, though this doesn't establish densities were this low historically, since only live trees were included in this study.

In addition, data from the General Land Office (GLO) survey conducted in 1865 verify this more open condition. The combination of data from this study, the open growth form of many trees, and the GLO survey data, all lend evidence towards the existence of a savanna at Jim's Creek prior to Euro-American settlement.

Succession

At Jim's Creek, 67% of the currently living trees established 75-125 years ago (Figure 8). A single cohort has been defined as at least 50% of the trees in a sampled area establishing within a 50-year period (Wong 1999). Using this definition, the forest at Jim's Creek is a single cohort, the result of a recruitment event occurring from 75-125 years ago.

The oldest trees established 350-375 years ago, which is similar to the oldest trees found at Rigdon meadows, an area less than 15 km from Jim's Creek (Hadley 1999). This also coincides with other data indicating that most of the oldest trees in the western Oregon Cascades established in the early to mid-1600s (Whitlock and Knox 2002).

Oregon white oaks are frequently out-competed and relegated to exposed, rocky ridges where they are considered a climax species (Howard 1992). They are also considered a climax species in the presence of frequent fires. In the absence of fire, however, oak is seral to Douglas-fir and other conifers (Franklin and Dyrness 1988; Howard 1992). Though they can reproduce under their own shade, oaks are intolerant of shading by conifers, and are frequently overtopped. Once overtopped, they enter a period of decline, eventually resulting in mortality. Most oaks at Jim's Creek appear to be in a state of severe decline, likely due to competition from conifers. Without intervention, they will almost certainly die soon. There are no living oaks of sapling stage or larger that are less than 50 years old in any community type sampled at Jim's Creek, leading to further site-scale declines of oaks. The areas that appear to be edaphically sufficient for oaks to grow, such as forests and woodlands, are too shaded, while meadows, which do provide enough light, are too edaphically poor for oaks and other trees to exist.

Though low tree densities historically characterized Jim's Creek, the reduction in frequency and scale of fires likely increased tree densities considerably across the site. It appears that, in the absence of significant disturbance, all suitable habitats for tree growth were quickly colonized by Douglas-fir, leading to increased density and effectively eliminating any further major recruitment events from occurring. Today, the forest at Jim's Creek is a result of this quick colonization event and a 75-125 year old cohort dominates the vegetation. The recent increase in recruitment during the last 25 years (Figures 8 and 9) may reflect canopy thinning of this cohort, or alternatively, unidentified climate events.

Community Differences Near Meadows

Proximity to the meadow areas at Jim's Creek appears to strongly influence historical and current plant community composition. The meadows have greater amounts of exposed rock, surface rock and few trees, likely due to low soil depth. Both pre-settlement and post-settlement tree species composition vary with proximity to a meadow area (Figure 8). For example, current forest and woodland communities, by definition located at least 45 m from a meadow area, show increased pre-settlement tree species diversity, as compared to other community types. Forests and woodlands are the only communities to contain significant pre-settlement Douglas-fir (73% of total pre-settlement trees in forests, 25% in woodlands) and show larger amounts of post-settlement Douglas-fir than other community types (80% and 75% of total post-settlement trees in forests and woodlands, respectively) (Figure 8 and Table 5). However, closer to the meadow areas (within 45 m), pre-settlement trees are composed principally of oak (100% of south meadow edges, 53% of north meadow edges and 67% of transition zones), with small amounts of pine (44% of north meadow edges and 14% of transition zones) and almost no Douglas-fir (0% for both meadow edges and 4% for transition zones) (Table 5).

Interestingly, south meadow edges, which have no pre-settlement ponderosa pine, now have the highest post-settlement ponderosa pine density of any community type (104 trees/ha) (Table 5). Conversely, forests and woodlands, which have the highest proportion of pre-settlement ponderosa pine (79% and 74% of total pre-settlement trees, respectively), have the lowest post-settlement ponderosa pine density (23 trees/ha and 3 trees/ha, respectively) (Table 5). This likely reflects ongoing succession, with ponderosa pine only initiating in areas with sufficient light and soil moisture, such as south meadow edges, while the forest and woodland areas are too shaded and dominated by Douglas-fir for ponderosa pine to initiate. In the mid-elevation mesic forests of the Cascades, ponderosa pine is considered an early seral species and without frequent fire, it eventually succeeds to Douglas-fir and true fir (Burns and Honkala 1990).

Growth Rates

The comparatively low growth rate of oak (0.21 cm/year) is likely a factor in its continued decline across the site. Ponderosa pine and Douglas-fir grow at considerably faster rates (0.49 cm/year and 0.42 cm/year, respectively), and easily out-compete the oaks.

Neither the growth rate ANOVA nor the multiple regression analysis shows significant differences in growth rate by community type or environmental variable. This likely indicates that suppression of tree recruitment by fire was more important than the slowing of growth by environmental site factors in controlling succession to forest. The controls of growth rate across the site warrant further study.

Meadow Invasion

The south meadow edges display age and species composition consistent with ongoing meadow invasion. High numbers of young (< 25 years) saplings dominate the current age distribution in south meadow plots. All meadows at Jim's Creek are situated in a south-southwest facing aspect, leaving the southern edge as the only shaded portion of a meadow, an important feature during the hot, dry summers. Older trees on the southern edges of meadows can create a “nursing” effect, lending shade and protection to create suitable habitat for further tree recruitment. Age distributions from the south meadow plots show consistent recruitment occurring over the past 125 years, with a wide range of age classes. The high numbers of young trees and saplings seen today may be a continuous occurrence within this community type, with a high portion of the saplings eventually dying off due to competition, reducing tree densities to levels similar to those in the 25-125 year age classes (50-100 trees/ha).

Transition plots show higher numbers of living oaks, with the youngest trees occurring in the 75-100 year age class. As mentioned earlier, oaks in these areas may be considered early seral species, living in fairly harsh conditions and eventually creating suitable habitat for conifer growth (Franklin and Dyrness 1988).

North meadow edges show density and age distributions that are consistent with the harsh, dry conditions that appear to characterize this community. They have the lowest density of any community type (336 tree/ha). It seems that trees have a difficult time establishing in this community, but once established, are able to take full advantage of the southern exposure afforded to them. There is generally little shade or other factors producing suitable habitat for tree establishment in the meadow portion of this community. Occasionally a tree may fall southward into the meadow and produce a small amount of habitat for tree recruitment to occur. Otherwise, little recruitment occurs on these sites.

Several studies have looked at meadow invasion, but few have looked at the low elevation meadows of the Cascades, particularly those with Oregon white oak as a major species (Taylor 1990; Miller & Halpern 1998; Hadley 1999). At Rigdon Meadows, an area less than 15 km from Jim's Creek and near the same elevation, meadow invasion was not found to be occurring (Hadley 1999).

Fire

Franklin and Dyrness (1988) describe a *Pinus-Quercus-Pseudotsuga* zone that occupies the Willamette Valley and is considered "semi-natural" in character because of the human influences, both historically and presently, that are necessary for its creation and maintenance. The mosaic of community types that currently characterize Jim's Creek, and the evidence of a prior savanna, are both likely reflections of a disturbance regime that historically included frequent fire.

Fire is thought to be the primary event responsible for creation and maintenance of grassland and oak savanna communities throughout the Willamette Valley (Johannessen et al. 1971; Franklin and Dyrness 1988). Within the Jim's Creek area, seven fire ignitions have occurred due to lightning since 1970. Five of these produced small fires ($<$ 0.05 ha) with little or no tree mortality. One was approximately 2.8 ha, and the latest one was a low-severity underburn of 26 ha that caused less than 10% mortality within the area (T. Bailey, personal communication, 2005). All fires were actively suppressed. At Rigdon Meadows, the pre-settlement mean fire return interval was found to be 8 years (Hadley 1999). Given this high rate of lightning caused fire (7 within the past 35 years at Jim's Creek), it is likely that without active suppression, some of these fires would effectively thin out the stand, leading towards savanna-like conditions where frequent, low-severity fires maintain meadows and low densities of fire-resistant trees, such as Oregon white oak, ponderosa pine and Douglas-fir (Cole 1977).

In addition, there is evidence of human habitation at Jim's Creek prior to Euro-American settlement (circa 1850). Several large diameter ponderosa pines have scars from peeled bark (Winkler and Bailey 2002), similar to those seen at Rigdon meadows (Hadley 1999). Given the evidence of human altered fire regimes from other sites in the Willamette River valley (Whitlock and Knox 2002; Winkler and Bailey 2002), it is reasonable to assume that humans likely had an effect on the fire regime at Jim's Creek. With additional anthropogenic sources of fire, an already short natural fire return interval would be shortened further. Evidence for high frequency, low intensity ground fires is difficult to find in trees, since such fires would not likely be intense enough to create a scar (Agee 1993). However, the patterns of vegetation and historical existence of savanna conditions suggests that Jim's Creek had a very short return interval of low-intensity fires.

With the establishment of the Cascade Forest Reserve in 1893, wide-scale fire suppression began in the area (Teensma 1987). The majority of trees at Jim's Creek established 100-125 years ago, which coincides with this date, and is likely the result of a changing fire regime.

CHAPTER VI

CONCLUSION

Jim's Creek was once likely a savanna composed of very low densities of Oregon white oak, ponderosa pine and Douglas-fir. A 3326% population difference between post-settlement and pre-settlement trees, and significant differences in species composition characterize the current forest. Oregon white oak is now a minor component (2%) of the Jim's Creek forest, and Douglas-fir is dominant (76%). Extensive sampling of tree ages across community types scattered throughout the site and the use of a Monte Carlo simulation have shown that these differences exist across the major plant community types. However, current meadow edges have been significantly more difficult for Douglas-fir to invade, probably because of harsh edaphic conditions such as shallow soil and low soil moisture during the dry summers in this region. These areas have also retained higher numbers of living oaks. South meadow edges display age distributions that are consistent with ongoing meadow invasion.

Through the analysis of pre-settlement savanna structure and successional trends, a dynamic picture of a historical oak-pine-fir savanna community has been created. Jim's Creek is an ideal site for studying the importance of oak savanna habitats and how they have changed in recent history. No logging or significant disturbance appears to have occurred on the areas sampled for this study since Euro-American settlement, and the historical tree record is intact. This study provides valuable data for furthering our understanding of rapidly disappearing savanna habitats, and will inform future management decisions and goals to restore and maintain oak savanna throughout the Willamette Valley and Pacific Northwest. Land managers and others seeking to restore or maintain current oak savanna stands need information on the structure and composition of these areas before landscape-wide changes began taking place. The results of this study provide sound data on the historical structure and recent successional trends that have characterized high elevation oak savanna ecosystems.

Without fire or mechanical clearing, Jim's Creek and other similar sites will continue as Douglas-fir forests, with a few oaks perhaps surviving in harsh edaphic conditions. Some ponderosa pine will also persist in the drier areas. The large expanses of savanna which once characterized this region will continue to be lost unless fire, a critical element to the creation and maintenance of savannas, is re-introduced, or surrogate disturbances such as repeated mechanical clearing are used in their place.

APPENDIX A

MONTE CARLO SIMULATION CODE

```
# Monte Carlo Simulation for Jim's Creek
# (C) 2005  Jonathan W Day
#
# Written for use in the R Statistics Package (http://www.r-project.org/)
#
# Two files are needed to run the simulation:
# 1 - mech_summary.csv (contains tree tallies for each plot)
#     should be loaded into R under the variable name 'mech_summary'
# 2 - datasheet.csv (contains age data from cored trees)
#     should be loaded into R under the variable name 'datasheet'
#
# See individual files for format and field names
#
# To run:
#   1.  Run the command 'mech_summary <- read.csv(file.choose())' and choose the
  mech_summary.csv file
#   2.  Run the command 'datasheet <- read.csv(file.choose())' and choose the
  datasheet.csv file
#   3.  Copy everything below the "###### BEGIN #####' line and paste into R
#   4.  Run times can be on the order of hours, so be patient.  When completed, there
  will be 5 output
#        files created in a CSV format - one for each community type.
#
###### BEGIN ######

# list of community types we are interested in
comm_types <- c("woodland","sedge","nedge", "transition", "forest")
# make the species_types match up with the row numbers from the mech_summary
species_types <- c("","","","PSME", "PIPO", "CADE", "QUGA")

for (chosen_comm_type in comm_types) {
  ages <- numeric()
  dbhs <- numeric()
  specs <- character()
  plotname <- character()
  community_type <- character()
  run <- numeric()
   aspect <- numeric()
  slope <- numeric()
  cancov <- numeric()
  density <- numeric()
  elev <- numeric()
  exp_rock <- numeric()
  sur_rock <- numeric()

  # Select cores which match the community we are interested in
  comm_type_cores <- datasheet[which(datasheet$COMM_TYPE==chosen_comm_type),]
  plot_names <- unique(comm_type_cores$MECH_TRANS)
  plot_names <- as.character(plot_names[which(plot_names != "")])
```

```
# Cycle through each plot that exists within the community
for (plot_id in plot_names) {

# Extract the tree tallies for this plot
 plot_id_counts <- mech_summary[which(mech_summary$Transect==plot_id),]

 # Run the simulation 50 times
 for (numruns in 1:50) {
    # Go through each size class within the plot
    for (x in 1:6) {
       # Get the total counts for the size class we are working on
       size_tree_count <- plot_id_counts[which(plot_id_counts$Size.class==x),]

       # And then get a list of cores that are from that size class
       size_class_cores <- comm_type_cores[which(comm_type_cores$SIZE.CLASS==x),]

       # Now go through every species and assign an age to each tree
       for (sp in 4:7) {
          # 4-PSME,...7-QUGA for the mech_summary
          species_tree_count <- sum(size_tree_count[,sp])

          # establish a list of suitable ages for the tree we are interested in
          eligible_cores <-
             size_class_cores[which(size_class_cores$SPECIES==species_types[sp]),]

          # If we are dealing with QUGAs, just use any available cores
          if (sp == 7) {
             eligible_cores <- datasheet[which(datasheet$SPECIES==species_types[sp]),]
          }
          # If dealing with big trees (size class 6) disregard community type
          if (x == 6) {
             eligible_cores <- datasheet[which(datasheet$SPECIES==species_types[sp]),]
             eligible_cores <- eligible_cores[which(eligible_cores$SIZE.CLASS==x),]
          }
          # Saplings - just assign an age
          if (x == 1) {
             age_sample <- sample(round((runif(100)*100) %% 10) + 5,
                species_tree_count, replace=T)
             dbh_sample <- sample(round((runif(100)*100) %% 3) + 1,
                species_tree_count, replace=T)
             spec_sample <- rep(species_types[sp], species_tree_count)
             plot_sample <- rep(plot_id, species_tree_count)
             run_sample <- rep(numruns, species_tree_count)
             community_type_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $COMM_TYPE[1], species_tree_count)
             aspect_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $ASPECT[1], species_tree_count)
             slope_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $SLOPE[1], species_tree_count)
             cancov_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $CANCOV[1], species_tree_count)
             density_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $DENSITY[1], species_tree_count)
             elev_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $ELEV[1], species_tree_count)
             exp_rock_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $EXP_ROCK[1], species_tree_count)
             sur_rock_sample <-
                rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
                $SUR_ROCK[1], species_tree_count)
```

```
}
# It's not a sapling, oak or big tree, so randomly assign an age to the
# tree and also copy all the relevant environmental data
else {
   # Make sure there is an actual core for this species and size class
   if (length(eligible_cores$FINAL_AGE) > 0) {
      age_sample <- sample(eligible_cores$FINAL_AGE, species_tree_count,
         replace=T)
      dbh_sample <- sample(eligible_cores$DBH, species_tree_count, replace=T)
      spec_sample <- rep(species_types[sp], species_tree_count)
      plot_sample <- rep(plot_id, species_tree_count)
      run_sample <- rep(numruns, species_tree_count)
      community_type_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $COMM_TYPE[1], species_tree_count)
      aspect_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $ASPECT[1], species_tree_count)
      slope_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $SLOPE[1], species_tree_count)
      cancov_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $CANCOV[1], species_tree_count)
      density_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $DENSITY[1], species_tree_count)
      elev_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $ELEV[1], species_tree_count)
      exp_rock_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $EXP_ROCK[1], species_tree_count)
      sur_rock_sample <-
         rep(regression_data[which(regression_data$MECH_TRANS==plot_id),]
         $SUR_ROCK[1], species_tree_count)
   }
   # There was no cored tree that match the community type, species and
   # size class we needed, so assign NA
   else {
      age_sample <- NA
      dbh_sample <- NA
      spec_sample <- NA
      plot_sample <- NA
      run_sample <- NA
      community_type_sample <- NA
      aspect_sample <- NA
      slope_sample <- NA
      cancov_sample <- NA
      density_sample <- NA
      elev_sample <- NA
      exp_rock_sample <- NA
      sur_rock_sample <- NA
   }
}
# Create a big list of all the ages and other data for this plot
ages <- append(ages, age_sample)
dbhs <- append(dbhs, dbh_sample)
specs <- append(specs, spec_sample)
plotname <- append(plotname, plot_sample)
run <- append(run, run_sample)
community_type <- append(community_type, community_type_sample)
aspect <- append(aspect, aspect_sample)
slope <- append(slope, slope_sample)
cancov <- append(cancov, cancov_sample)
density <- append(density, density_sample)
elev <- append(elev, elev_sample)
```

```
            exp_rock <- append(exp_rock, exp_rock_sample)
            sur_rock <- append(sur_rock, sur_rock_sample)
         }  # species
      }  # size class
   }  # numruns
  } # plot id

  # Remove any NAs
  ages <- na.omit(ages)
  dbhs <- na.omit(dbhs)
  specs <- na.omit(specs)
  plotname <- na.omit(plotname)
  run <- na.omit(run)
  community_type <- na.omit(community_type)
  aspect <- na.omit(aspect)
  slope <- na.omit(slope)
  cancov <- na.omit(cancov)
  density <- na.omit(cancov)
  elev <- na.omit(elev)
  exp_rock <- na.omit(exp_rock)
  sur_rock <- na.omit(sur_rock)

  # Write out the csv file containing all the trees and ages for this community type
  output_data <- data.frame(plotname,dbhs,ages,specs,community_type, run, aspect, slope,
  cancov, density, elev, exp_rock, sur_rock)

  write.csv(output_data, chosen_comm_type)

} # community type
```

APPENDIX B

TREE AGE DATA

Tree Tag	Transect	Study Plot	Species	dbh	Age	Growth Rate	Community Type
182	4N		PIPO	102	196	0.5204	woodland
184	4N	4N-60	PIPO	181	260	0.6962	forest
466			PIPO	32.5	107	0.3037	woodland
136	4N		PSME	104	117	0.8889	forest
A446			PIPO	81.5	161	0.5062	forest
52	7N		PIPO	104	247	0.4211	woodland
12	7N		PIPO	85	229	0.3712	woodland
62	3N	3N-240	PIPO	174	212	0.8208	forest
151	2N		PSME	113	295	0.3831	forest
162	2N		PIPO	111	255	0.4353	forest
163	2N		PIPO	106	223	0.4753	forest
164	2N		PSME	108	148	0.7297	forest
165	2N		PSME	129	265	0.4868	forest
176	2N		PSME	109	279	0.3907	forest
177	2N		PSME	103	283	0.3640	forest
178	2N		PSME	107	314	0.3408	forest
180	2N		PSME	161	287	0.5610	forest
79	4S		PSME	124	236	0.5254	forest
78	4S		PSME	120	194	0.6186	forest
59	8N		PSME	106	130	0.8154	woodland
57	8N	8N-120	PIPO	110	221	0.4977	woodland
53	8N		PIPO	112	245	0.4571	woodland
56	7N	7N-540	PIPO	122	265	0.4604	forest
53	7N		PIPO	122	240	0.5083	woodland
40	7N	7N-360	PIPO	106	228	0.4649	woodland
75	4S		PSME	129	306	0.4216	forest
53	4S		PILA	157	210	0.7476	forest
83	4S		PSME	117	246	0.4756	forest
63	4S		PIPO	106	316	0.3354	woodland
49	4S		PSME	116	291	0.3986	woodland
52	4S		PIPO	96	261	0.3678	forest
3s35.5	3S		PIPO	120	232	0.5172	forest
68	3S		PIPO	101	257	0.3930	woodland
70	4S		PSME	106	256	0.4141	forest
73	4S		PSME	100	245	0.4082	woodland
67	4S		PSME	115	159	0.7233	woodland
34(1)	7N		QUGA	33	247	0.1336	meadow - north edge
513	3N		QUGA	29	132	0.2197	meadow - north edge
501	3N		QUGA	36	128	0.2813	meadow - north edge
511	3N		QUGA	80	338	0.2367	meadow - north edge
87	4N	4N-120	QUGA	18	113	0.1593	meadow - south edge

Tree Tag	Transect	Study Plot	Species	dbh	Age	Growth Rate	Community Type
185	4N	4N-120	QUGA	24	117	0.2051	meadow - south edge
56	3N		QUGA	26	113	0.2301	meadow - north edge
57	3N		QUGA	26	137	0.1898	meadow - north edge
513	3N		QUGA	29	133	0.2180	meadow - north edge
4N-418	4N		PSME	86	115	0.7478	forest
92	3N		QUGA	60	206	0.2913	meadow - south edge
3	3N		QUGA	40	100	0.4000	meadow - north edge
33	7N		QUGA	17	119	0.1429	meadow - south edge
972	4N-60	4N-60	PSME	83.75	113	0.7412	forest
93	4N-60	4N-60	PSME	86	110	0.7818	forest
973	4N-60	4N-60	PSME	48.5	93	0.5215	forest
974	4N-60	4N-60	PSME	60	90	0.6667	forest
964	4N-60	4N-60	PSME	63	108	0.5833	forest
976	4N-60	4N-60	PSME	29	63	0.4603	forest
975	4N-60	4N-60	PSME	8	32	0.2500	forest
967	4N-60	4N-60	PSME	4.5	23	0.1957	forest
996	4N-120	4N-120	PIPO	38	110	0.3455	meadow - south edge
994	4N-120	4N-120	PIPO	65	103	0.6311	meadow - south edge
993	4N-120	4N-120	PSME	28	56	0.5000	meadow - south edge
987	4N-120	4N-120	PSME	15	64	0.2344	meadow - south edge
980	4N-120	4N-120	PSME	71	106	0.6698	meadow - south edge
997	4N-120	4N-120	ABGR	7	21	0.3333	meadow - south edge
981	4N-120	4N-120	PSME	79	111	0.7117	meadow - south edge
992	4N-120	4N-120	PIPO	89	117	0.7607	meadow - south edge
989	4N-120	4N-120	PIPO	92	113	0.8142	meadow - south edge
995	4N-300	4N-300	PIPO	66	136	0.4853	forest
402	4N-300	4N-300	PSME	62	104	0.5962	forest
982	4N-300	4N-300	PILA	30	95	0.3158	forest
977	4N-300	4N-300	PIPO	39	137	0.2847	forest
965	4N-300	4N-300	PSME	20	94	0.2128	forest
978	4N-300	4N-300	PSME	14.5	63	0.2302	forest
988	7N-0	7N-0	PSME	75.5	126	0.5992	forest
985	7N-0	7N-0	PSME	57	120	0.4750	forest
991	7N-0	7N-0	CADE	18.5	113	0.1637	forest
990	7N-0	7N-0	PSME	26	107	0.2430	forest
983	7N-0	7N-0	PSME	72	136	0.5294	forest
979	7N-0	7N-0	CADE	27	129	0.2093	forest
403	7N-0	7N-0	PSME	22	126	0.1746	forest
969	7N-60	7N-60	PSME	9	29	0.3103	meadow - south edge
966	7N-60	7N-60	CADE	52	79	0.6582	meadow - south edge
401	7N-60	7N-60	PSME	43	72	0.5972	meadow - south edge
968	7N-60	7N-60	CADE	9	95	0.0947	meadow - south edge
2	7N-60	7N-60	PSME	39.5	120	0.3292	meadow - south edge
984	7N-60	7N-60	PIPO	52	130	0.4000	meadow - south edge
958	7N-120	7N-120	PSME	83	124	0.6694	meadow - north edge
957	7N-120	7N-120	PSME	11	114	0.0965	meadow - north edge
970	7N-120	7N-120	PIPO	29	75	0.3867	meadow - north edge
986	7N-120	7N-120	PIPO	15	79	0.1899	meadow - north edge
950	7N-120	7N-120	PSME	33	109	0.3028	meadow - north edge
952	7N-120	7N-120	PSME	73	126	0.5794	meadow - north edge
962	7N-120	7N-120	PIPO	66	157	0.4204	meadow - north edge
963	7N-180	7N-180	PSME	76	134	0.5672	forest
961	7N-180	7N-180	PIPO	66	125	0.5280	forest
953	7N-180	7N-180	PSME	39.5	98	0.4031	forest
949	7N-180	7N-180	PSME	17	78	0.2179	forest
956	7N-180	7N-180	CADE	7.5	82	0.0915	forest
959	7N-180	7N-180	PSME	39	104	0.3750	forest
951	7N-180	7N-180	PSME	60	127	0.4724	forest
947	7N-360	7N-360	PSME	64	114	0.5614	woodland

Tree Tag	Transect	Study Plot	Species	dbh	Age	Growth Rate	Community Type
929	7N-360	7N-360	CADE	28	95	0.2947	woodland
946	7N-360	7N-360	PSME	47	112	0.4196	woodland
948	7N-360	7N-360	PSME	23.5	108	0.2176	woodland
933	7N-360	7N-360	CADE	14.5	105	0.1381	woodland
940	7N-540	7N-540	PSME	74	114	0.6491	forest
945	7N-540	7N-540	PSME	52	99	0.5253	forest
944	7N-540	7N-540	PSME	21	47	0.4468	forest
930	7N-540	7N-540	PSME	35	104	0.3365	forest
927	7N-540	7N-540	PSME	33	120	0.2750	forest
936	7N-540	7N-540	PSME	10	103	0.0971	forest
960	2N-60	2N-60	PSME	24	99	0.2424	forest
934	2N-60	2N-60	CADE	12	100	0.1200	forest
955	2N-60	2N-60	PSME	57	108	0.5278	forest
954	2N-60	2N-60	PSME	65	114	0.5702	forest
925	2N-60	2N-60	PSME	39	105	0.3714	forest
926	2N-60	2N-60	PSME	34.5	89	0.3876	forest
931	2N-120	2N-120	PIPO	50	107	0.4673	forest
924	2N-120	2N-120	PSME	59	103	0.5728	forest
939	2N-120	2N-120	PSME	61	92	0.6630	forest
935	2N-120	2N-120	CADE	8.5	100	0.0850	forest
941	2N-120	2N-120	PSME	19	106	0.1792	forest
943	2N-120	2N-120	PSME	40	105	0.3810	forest
937	2N-180	2N-180	PSME	55	77	0.7143	forest
942	2N-180	2N-180	ABGR	15.5	88	0.1761	forest
928	2N-180	2N-180	PSME	18.5	100	0.1850	forest
920	2N-180	2N-180	PSME	66	120	0.5500	forest
916	2N-180	2N-180	PSME	43	106	0.4057	forest
406	2N-240	2N-240	PSME	76	132	0.5758	forest
971	2N-240	2N-240	PSME	51	105	0.4857	forest
904	2N-240	2N-240	PSME	57	126	0.4524	forest
917	2N-240	2N-240	PSME	35	121	0.2893	forest
918	2N-240	2N-240	PSME	75.5	119	0.6345	forest
913	2N-240	2N-240	PSME	11.5	91	0.1264	forest
907	2N-240	2N-240	PSME	46	123	0.3740	forest
909	2N-240	2N-240	PSME	24	111	0.2162	forest
39	8N-360	8N-360	PSME	22	107	0.2056	woodland
35	8N-360	8N-360	PIPO	49	102	0.4804	woodland
36	8N-360	8N-360	PSME	56	105	0.5333	woodland
34	8N-360	8N-360	PSME	41	100	0.4100	woodland
37	8N-360	8N-360	CADE	11	71	0.1549	woodland
2	8N-360	8N-360	PSME	57	123	0.4634	woodland
11	8N-240	8N-240	PSME	61	119	0.5126	woodland
29	8N-240	8N-240	PSME	34	107	0.3178	woodland
12	8N-240	8N-240	PSME	13	92	0.1413	woodland
27	8N-240	8N-240	PSME	31	102	0.3039	woodland
26	8N-240	8N-240	CADE	15	104	0.1442	woodland
17	8N-120	8N-120	PSME	67	74	0.9054	woodland
13	8N-120	8N-120	PSME	76	105	0.7238	woodland
5	8N-120	8N-120	PSME	33	103	0.3204	woodland
24	8N-120	8N-120	PSME	43	101	0.4257	woodland
28	8N-120	8N-120	PSME	22	87	0.2529	woodland
19	8N-120	8N-120	PSME	55	70	0.7857	woodland
18	8N-60	8N-60	PSME	55	99	0.5556	meadow - north edge
30	8N-60	8N-60	PIPO	77	211	0.3649	meadow - north edge
32	8N-60	8N-60	PSME	24	99	0.2424	meadow - north edge
3	8N-60	8N-60	PSME	57	101	0.5644	meadow - north edge
22	8N-60	8N-60	PSME	27	103	0.2621	meadow - north edge
33	8N-60	8N-60	PSME	13	94	0.1383	meadow - north edge
9	8N-60	8N-60	PSME	45	103	0.4369	meadow - north edge

Tree Tag	Transect	Study Plot	Species	dbh	Age	Growth Rate	Community Type
23	3N-60	3N-60	PIPO	61	101	0.6040	meadow - south edge
1	3N-60	3N-60	PSME	14.5	92	0.1576	meadow - south edge
16	3N-60	3N-60	PSME	28	98	0.2857	meadow - south edge
6	3N-60	3N-60	PSME	53	105	0.5048	meadow - south edge
25	3N-60	3N-60	PSME	86	111	0.7748	meadow - south edge
4	3N-60	3N-60	PSME	5	17	0.2941	meadow - south edge
20	3N-60	3N-60	PSME	45	107	0.4206	meadow - south edge
Jul-63	3N-120	3N-120	PIPO	86	105	0.8190	meadow - north edge
21	3N-120	3N-120	PIPO	18	88	0.2045	meadow - north edge
14	3N-120	3N-120	PIPO	54	93	0.5806	meadow - north edge
60	3N-120	3N-120	PSME	77	105	0.7333	meadow - north edge
10	3N-120	3N-120	PIPO	45	106	0.4245	meadow - north edge
31	3N-120	3N-120	PSME	20	92	0.2174	meadow - north edge
15	3N-120	3N-120	PSME	62	101	0.6139	meadow - north edge
38	3N-120	3N-120	PSME	35	96	0.3646	meadow - north edge
908	3N-180	3N-180	PSME	43	88	0.4886	forest
901	3N-180	3N-180	PSME	83	99	0.8384	forest
8	3N-180	3N-180	PSME	66	102	0.6471	forest
201	3N-180	3N-180	PIPO	85	105	0.8095	forest
202	3N-180	3N-180	PSME	87	108	0.8056	forest
922	3N-180	3N-180	PSME	13	47	0.2766	forest
62	3N-180	3N-180	PSME	77	106	0.7264	forest
911	3N-180	3N-180	PSME	61	93	0.6559	forest
61	3N-180	3N-180	CADE	89	99	0.8990	forest
902	3N-180	3N-180	ABGR	5.5	24	0.2292	forest
903	3N-240	3N-240	PIPO	60	108	0.5556	forest
915	3N-240	3N-240	PSME	28	73	0.3836	forest
923	3N-240	3N-240	PIPO	73	105	0.6952	forest
919	3N-240	3N-240	PSME	40	103	0.3883	forest
912	3N-240	3N-240	PSME	13	96	0.1354	forest
206	3N-240	3N-240	PSME	78	102	0.7647	forest
906	3N-240	3N-240	PSME	61	103	0.5922	forest
914	3N-240	3N-240	PSME	8.5	29	0.2931	forest
910	3N-360	3N-360	PSME	53	103	0.5146	meadow - north edge
921	3N-360	3N-360	PSME	55	104	0.5288	meadow - north edge
905	3N-360	3N-360	PSME	28	104	0.2692	meadow - north edge
33	3N-360	3N-360	PIPO	28	97	0.2887	meadow - north edge
15	3N-360	3N-360	CADE	6	23	0.2609	meadow - north edge
212	4N-240	4N-240	PIPO	76	149	0.5101	meadow - north edge
13	4N-240	4N-240	PSME	48	57	0.8421	meadow - north edge
100	4N-240	4N-240	PSME	39	56	0.6964	meadow - north edge
10	4N-240	4N-240	PIPO	58	55	1.0545	meadow - north edge
20	4N-240	4N-240	PIPO	22	39	0.5641	meadow - north edge
16	4N-240	4N-240	PIPO	12	32	0.3750	meadow - north edge
224	3S-0	3S-0	PSME	77	129	0.5969	forest
23	3S-0	3S-0	PSME	53	125	0.4240	forest
192	3S-0	3S-0	PSME	41	104	0.3942	forest
19	3S-0	3S-0	PSME	18.5	104	0.1779	forest
225	3S-0	3S-0	PSME	80	121	0.6612	forest
24	3S-0	3S-0	PIPO	52	132	0.3939	forest
18	3S-0	3S-0	PSME	8.5	83	0.1024	forest
27	3S-0	3S-0	PSME	83	126	0.6587	forest
26	3S-0	3S-0	PSME	40	117	0.3419	forest
28	3S-60	3S-60	PIPO	66	131	0.5038	forest
99	3S-60	3S-60	PSME	58.5	104	0.5625	forest
199	3S-60	3S-60	ABGR	34	108	0.3148	forest
196	3S-60	3S-60	PSME	17.5	68	0.2574	forest
21	3S-60	3S-60	PIPO	44	127	0.3465	forest
29	3S-60	3S-60	PSME	16.5	77	0.2143	forest

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238	3S-180	3S-180	PIPO	97	296	0.3277	forest
237	3S-180	3S-180	PSME	104	207	0.5024	forest
94	3S-180	3S-180	PSME	74	203	0.3645	forest
193	3S-180	3S-180	PSME	62	139	0.4460	forest
98	3S-180	3S-180	PSME	33	119	0.2773	forest
25	3S-180	3S-180	PSME	17	106	0.1604	forest
30	3S-180	3S-180	PSME	14.5	112	0.1295	forest
14	3S-180	3S-180	PSME	32	130	0.2462	forest
879	4S-240	4S-240	CADE	57	106	0.5377	woodland
900	4S-240	4S-240	PSME	18	98	0.1837	woodland
874	4S-240	4S-240	CADE	46	95	0.4842	woodland
878	4S-240	4S-240	PSME	35	111	0.3153	woodland
863	4S-240	4S-240	CADE	9	98	0.0918	woodland
872	4S-240	4S-240	CADE	56	95	0.5895	woodland
868	4S-360	4S-360	PSME	8.5	94	0.0904	forest
869	4S-360	4S-360	PSME	82	298	0.2752	forest
875	4S-360	4S-360	PSME	50	121	0.4132	forest
881	4S-360	4S-360	CADE	28	116	0.2414	forest
871	4S-360	4S-360	CADE	6.5	86	0.0756	forest
892	4S-360	4S-360	PSME	52	374	0.1390	forest
890	4S-360	4S-360	PSME	56	263	0.2129	forest
886	4S-480	4S-480	PSME	18	114	0.1579	forest
885	4S-480	4S-480	PSME	66	129	0.5116	forest
866	4S-480	4S-480	PSME	36	135	0.2667	forest
898	4S-480	4S-480	PSME	68	128	0.5313	forest
880	4S-480	4S-480	PSME	8	82	0.0976	forest
883	4S-480	4S-480	PSME	37	118	0.3136	forest
889	4S-600	4S-600	PSME	17.5	109	0.1606	woodland
876	4S-600	4S-600	PSME	44	111	0.3964	woodland
888	4S-600	4S-600	CADE	13.5	101	0.1337	woodland
45	4S-600	4S-600	QUGA	14	180	0.0778	woodland
46	4S-600	4S-600	QUGA	10	97	0.1031	woodland
862	4S-600	4S-600	PSME	40	111	0.3604	woodland
407	7N-660	7N-660	PSME	33	105	0.3143	woodland
408	7N-660	7N-660	PSME	33	105	0.3143	woodland
408	7N-660	7N-660	PSME	30	100	0.3000	woodland
409	7N-660	7N-660	PSME	33	86	0.3837	woodland
410	7N-660	7N-660	PSME	25.5	99	0.2576	woodland
412	7N-660	7N-660	PSME	30.5	110	0.2773	woodland
414	7N-660	7N-660	CADE	57	111	0.5135	woodland
457	7N-660	7N-660	PSME	60.5	109	0.5550	woodland
A407	7N-660	7N-660	PSME	24.5	96	0.2552	woodland
A408	7N-660	7N-660	CADE	31	101	0.3069	woodland
A414	7N-660	7N-660	PSME	36	106	0.3396	woodland
417	7N-660	7N-660	PSME	60.5	116	0.5216	woodland
419	7N-660	7N-660	PSME	48.5	116	0.4181	woodland
420	7N-660	7N-660	PSME	39	134	0.2910	woodland
422	7N-660	7N-660	PSME	27	91	0.2967	woodland
423	7N-660	7N-660	PSME	45	123	0.3659	woodland
A417	7N-660	7N-660	PSME	29.5	106	0.2783	woodland
A423	7N-660	7N-660	PSME	46.5	137	0.3394	woodland
C428	7N-660	7N-660	CADE	12	80	0.1500	woodland
D428	7N-660	7N-660	PSME	18.5	59	0.3136	woodland
E428	7N-660	7N-660	CADE	10.5	89	0.1180	woodland
B439	7N-660	7N-660	CADE	17.5	109	0.1606	woodland
B418	7N-660	7N-660	PSME	23	86	0.2674	woodland
B428	7N-660	7N-660	PSME	29.5	124	0.2379	woodland
A439	7N-660	7N-660	PSME	27	104	0.2596	woodland
A424	7N-660	7N-660	PSME	24	76	0.3158	woodland

Tree Tag	Transect	Study Plot	Species	dbh	Age	Growth Rate	Community Type
A428	7N-660	7N-660	PSME	18	53	0.3396	woodland
A418	7N-660	7N-660	PSME	23	91	0.2527	woodland
424	7N-660	7N-660	PSME	31	89	0.3483	woodland
425	7N-660	7N-660	PSME	44.5	135	0.3296	woodland
426	7N-660	7N-660	PSME	70	78	0.8974	woodland
418	7N-660	7N-660	PSME	26	86	0.3023	woodland
428	7N-660	7N-660	PSME	39	132	0.2955	woodland
429	7N-660	7N-660	PSME	36.5	119	0.3067	woodland
439	7N-660	7N-660	PSME	58.5	119	0.4916	woodland
435	7N-660	7N-660	PSME	26.5	79	0.3354	woodland
A435	7N-660	7N-660	PSME	56	117	0.4786	woodland
442	7N-660	7N-660	PSME	63	119	0.5294	woodland
A443	7N-660	7N-660	CADE	24	94	0.2553	woodland
404	7N-660	7N-660	PSME	27	92	0.2935	woodland
444	7N-660	7N-660	PSME	32	80	0.4000	woodland
A444	7N-660	7N-660	PSME	42	112	0.3750	woodland
A447	7N-660	7N-660	PSME	51	122	0.4180	woodland
447	7N-660	7N-660	PSME	33	108	0.3056	woodland
864	293	293	PSME	51.5	101	0.5099	transition
894	293	293	QUGA	21	138	0.1522	transition
865	293	293	CADE	40	95	0.4211	transition
893	293	293	CADE	67	100	0.6700	transition
897	293	293	PSME	32	98	0.3265	transition
884	293	293	PSME	12.5	84	0.1488	transition
887	293	293	PSME	11	90	0.1222	transition
867	293	293	QUGA	26	151	0.1722	transition
877	290	290	PSME	25.5	119	0.2143	transition
861	290	290	PIPO	49	125	0.3920	transition
891	290	290	PSME	15	70	0.2143	transition
895	290	290	PSME	60	112	0.5357	transition
845	290	290	CADE	16.5	130	0.1269	transition
860	290	290	PSME	71	133	0.5338	transition
819	290	290	PSME	78	115	0.6783	transition
853	295	295	PSME	51	100	0.5100	transition
847	295	295	PSME	9	90	0.1000	transition
851	295	295	PIPO	98	120	0.8167	transition
828	295	295	PSME	38.5	103	0.3738	transition
873	295	295	PSME	69	112	0.6161	transition
836	295	295	PSME	35	108	0.3241	transition
804	295	295	PSME	10	99	0.1010	transition
832	288	288	PSME	86	107	0.8037	transition
829	288	288	PSME	7	81	0.0864	transition
826	288	288	PSME	28.5	82	0.3476	transition
849	288	288	PSME	71	101	0.7030	transition
827	288	288	PIPO	13.5	73	0.1849	transition
857	288	288	PIPO	46	104	0.4423	transition
807	285	285	PSME	64.5	129	0.5000	transition
802	285	285	PSME	83	131	0.6336	transition
817	285	285	PSME	24.5	108	0.2269	transition
816	285	285	CADE	7.5	91	0.0824	transition
810	285	285	PSME	46	125	0.3680	transition
848	285	285	CADE	33	121	0.2727	transition
803	285	285	PSME	65	128	0.5078	transition
840	286	286	PIPO	36	106	0.3396	transition
843	286	286	PIPO	85	120	0.7083	transition
830	286	286	PSME	32	83	0.3855	transition
805	299	299	PSME	75	98	0.7653	transition
812	299	299	PSME	49.5	101	0.4901	transition
815	299	299	PIPO	15	66	0.2273	transition

Tree Tag	Transect	Study Plot	Species	dbh	Age	Growth Rate	Community Type
854	299	299	PSME	7	72	0.0972	transition
808	299	299	PSME	27	92	0.2935	transition
834	299	299	QUGA	30	125	0.2400	transition
835	299	299	QUGA	20	99	0.2020	transition

APPENDIX C

TREE TALLY DATA

Transect	Community Type	Size Class	PSME	PIPO	CADE	QUGA	ABGR	PILA	TOTAL
4S-240	woodland	1	0	0	0	0	0	0	0
4S-240	woodland	2	21	0	22	0	0	0	43
4S-240	woodland	3	31	0	4	0	0	0	35
4S-240	woodland	4	3	0	4	0	0	0	7
4S-240	woodland	5	0	0	0	0	0	0	0
4S-240	woodland	6	0	0	0	0	0	0	0
4S-360	forest	1	0	0	0	0	0	0	0
4S-360	forest	2	26	0	37	0	0	0	63
4S-360	forest	3	15	0	1	0	0	0	16
4S-360	forest	4	2	0	0	0	0	0	2
4S-360	forest	5	5	1	0	0	0	0	6
4S-360	forest	6	1	1	0	0	0	0	2
4S-480	forest	1	7	0	5	0	0	1	13
4S-480	forest	2	9	0	2	0	1	0	12
4S-480	forest	3	9	0	0	0	0	0	9
4S-480	forest	4	6	0	0	0	0	0	6
4S-480	forest	5	0	0	0	0	0	0	0
4S-480	forest	6	0	0	0	0	0	0	0
4S-600	woodland	1	0	0	0	0	0	0	0
4S-600	woodland	2	31	0	7	4	0	0	42
4S-600	woodland	3	21	0	1	0	0	0	22
4S-600	woodland	4	0	0	0	0	0	0	0
4S-600	woodland	5	0	0	0	0	0	0	0
4S-600	woodland	6	1	0	0	0	0	0	1
2N-60	forest	1	1	0	0	0	0	0	1
2N-60	forest	2	25	0	3	0	0	0	28
2N-60	forest	3	14	0	1	0	0	0	15
2N-60	forest	4	7	0	0	0	0	0	7
2N-60	forest	5	0	0	0	0	0	0	0
2N-60	forest	6	0	0	0	0	0	0	0
2N-120	forest	1	0	0	0	0	0	0	0
2N-120	forest	2	20	1	4	1	0	0	26
2N-120	forest	3	25	1	1	0	0	0	27
2N-120	forest	4	3	0	0	0	0	0	3

Transect	Community Type	Size Class	PSME	PIPO	CADE	QUGA	ABGR	PILA	TOTAL
2N-120	forest	5	0	0	0	0	0	0	0
2N-120	forest	6	0	0	0	0	0	0	0
2N-180	forest	1	1	0	0	0	0	0	1
2N-180	forest	2	42	0	2	1	1	0	46
2N-180	forest	3	22	0	0	0	0	0	22
2N-180	forest	4	3	0	0	0	0	0	3
2N-180	forest	5	0	0	0	0	0	0	0
2N-180	forest	6	0	0	0	0	0	0	0
2N-240	forest	1	0	0	0	0	0	0	0
2N-240	forest	2	32	0	2	0	1	1	36
2N-240	forest	3	11	0	0	0	0	0	11
2N-240	forest	4	7	0	0	0	0	0	7
2N-240	forest	5	1	0	0	0	0	0	1
2N-240	forest	6	1	0	0	0	0	0	1
3S-0	forest	1	0	0	0	0	0	0	0
3S-0	forest	2	18	0	4	0	1	0	23
3S-0	forest	3	7	2	0	0	0	0	9
3S-0	forest	4	10	0	0	0	0	0	10
3S-0	forest	5	3	0	0	0	0	0	3
3S-0	forest	6	0	0	0	0	0	0	0
3S-60	forest	1	0	0	0	0	0	0	0
3S-60	forest	2	8	0	1	0	1	0	10
3S-60	forest	3	13	1	1	0	2	0	17
3S-60	forest	4	12	2	0	0	0	0	14
3S-60	forest	5	0	0	0	0	0	0	0
3S-60	forest	6	0	0	0	0	0	0	0
3S-180	forest	1	0	0	0	0	0	0	0
3S-180	forest	2	12	0	8	1	2	0	23
3S-180	forest	3	14	0	2	0	0	0	16
3S-180	forest	4	12	0	0	0	0	0	12
3S-180	forest	5	0	1	1	0	0	0	2
3S-180	forest	6	1	0	0	0	0	0	1
3N-60	meadow - south edge	1	28	6	4	0	4	0	42
3N-60	meadow - south edge	2	16	1	2	11	0	0	30
3N-60	meadow - south edge	3	3	0	1	0	0	0	4
3N-60	meadow - south edge	4	5	2	1	0	0	0	8
3N-60	meadow - south edge	5	0	0	0	0	0	0	0
3N-60	meadow - south edge	6	0	0	0	0	0	0	0
3N-120	meadow - north edge	1	0	0	0	0	0	0	0
3N-120	meadow - north edge	2	1	2	0	2	0	0	5
3N-120	meadow - north edge	3	3	3	0	1	0	0	7
3N-120	meadow - north edge	4	1	1	0	0	0	0	2
3N-120	meadow - north edge	5	1	2	0	2	0	0	5
3N-120	meadow - north edge	6	0	0	0	0	0	0	0
3N-180	forest	1	8	11	17	0	0	0	36
3N-180	forest	2	7	2	3	5	6	0	23
3N-180	forest	3	1	0	0	2	0	0	3
3N-180	forest	4	3	0	1	0	0	0	4
3N-180	forest	5	3	1	1	0	0	0	5

Transect	Community Type	Size Class	PSME	PIPO	CADE	QUGA	ABGR	PILA	TOTAL
3N-180	forest	6	0	0	0	0	0	0	0
3N-240	forest	1	6	1	0	0	0	0	7
3N-240	forest	2	20	0	3	0	0	0	23
3N-240	forest	3	13	1	2	0	0	0	16
3N-240	forest	4	9	2	1	0	0	0	12
3N-240	forest	5	1	0	0	0	0	0	1
3N-240	forest	6	0	1	0	0	0	0	1
3N-360	meadow - north edge	1	3	6	4	0	0	0	13
3N-360	meadow - north edge	2	1	1	1	14	0	0	17
3N-360	meadow - north edge	3	5	4	1	4	0	0	14
3N-360	meadow - north edge	4	2	0	0	0	0	0	2
3N-360	meadow - north edge	5	0	0	0	0	0	0	0
3N-360	meadow - north edge	6	0	0	0	0	0	0	0
4N-60	forest	1	22	2	0	0	0	0	24
4N-60	forest	2	65	0	0	0	0	0	65
4N-60	forest	3	4	0	0	0	0	0	4
4N-60	forest	4	4	0	0	0	0	0	4
4N-60	forest	5	2	0	0	0	0	0	2
4N-60	forest	6	0	1	0	0	0	0	1
4N-120	meadow - south edge	1	9	9	2	0	0	0	20
4N-120	meadow - south edge	2	53	7	0	2	1	0	63
4N-120	meadow - south edge	3	1	1	0	1	0	0	3
4N-120	meadow - south edge	4	1	1	0	0	0	0	2
4N-120	meadow - south edge	5	1	3	0	0	0	0	4
4N-120	meadow - south edge	6	0	0	0	0	0	0	0
4N-240	meadow - north edge	1	6	2	0	0	0	0	8
4N-240	meadow - north edge	2	3	8	0	1	0	0	12
4N-240	meadow - north edge	3	12	1	0	1	0	0	14
4N-240	meadow - north edge	4	0	1	0	0	0	0	1
4N-240	meadow - north edge	5	0	1	0	0	0	0	1
4N-240	meadow - north edge	6	0	0	0	0	0	0	0
4N-300	forest	1	0	0	0	0	0	0	0
4N-300	forest	2	47	0	0	0	0	0	47
4N-300	forest	3	21	3	0	0	0	2	26
4N-300	forest	4	2	1	0	0	0	0	3
4N-300	forest	5	0	0	0	0	0	0	0
4N-300	forest	6	1	0	0	0	0	0	1
7N-0	forest	1	0	0	0	0	0	0	0
7N-0	forest	2	7	0	21	0	0	1	29
7N-0	forest	3	24	0	10	0	0	0	34
7N-0	forest	4	13	0	1	0	0	0	14
7N-0	forest	5	0	0	0	0	0	0	0
7N-0	forest	6	0	0	0	0	0	0	0
7N-60	meadow - south edge	1	18	5	0	0	0	0	23
7N-60	meadow - south edge	2	5	0	1	2	0	0	8
7N-60	meadow - south edge	3	4	0	5	0	0	0	9
7N-60	meadow - south edge	4	0	1	4	0	0	0	5
7N-60	meadow - south edge	5	0	0	0	0	0	0	0
7N-60	meadow - south edge	6	0	0	0	0	0	0	0

Transect	Community Type	Size Class	PSME	PIPO	CADE	QUGA	ABGR	PILA	TOTAL
7N-120	meadow - north edge	1	0	3	0	0	0	0	3
7N-120	meadow - north edge	2	9	1	2	4	0	0	16
7N-120	meadow - north edge	3	9	2	2	0	0	0	13
7N-120	meadow - north edge	4	2	2	1	0	0	0	5
7N-120	meadow - north edge	5	1	0	0	0	0	0	1
7N-120	meadow - north edge	6	0	0	0	0	0	0	0
7N-180	forest	1	0	0	0	0	0	0	0
7N-180	forest	2	32	0	4	0	0	0	36
7N-180	forest	3	22	1	0	0	0	0	23
7N-180	forest	4	4	2	0	0	0	0	6
7N-180	forest	5	1	0	0	0	0	0	1
7N-180	forest	6	0	0	0	0	0	0	0
7N-360	woodland	1	0	0	0	0	0	0	0
7N-360	woodland	2	9	0	3	0	0	0	12
7N-360	woodland	3	18	0	1	0	0	0	19
7N-360	woodland	4	4	0	0	0	0	0	4
7N-360	woodland	5	0	0	0	0	0	0	0
7N-360	woodland	6	0	1	0	0	0	0	1
7N-540	forest	1	0	2	0	0	0	0	2
7N-540	forest	2	17	0	3	0	0	0	20
7N-540	forest	3	28	1	0	0	0	0	29
7N-540	forest	4	6	0	0	0	0	0	6
7N-540	forest	5	0	0	0	0	0	0	0
7N-540	forest	6	0	1	0	0	0	0	1
7N-660	woodland	1	0	0	0	0	0	0	0
7N-660	woodland	2	6	0	4	0	0	0	10
7N-660	woodland	3	25	0	1	0	0	0	26
7N-660	woodland	4	7	0	1	0	0	0	8
7N-660	woodland	5	0	0	0	0	0	0	0
7N-660	woodland	6	0	2	0	0	0	0	2
8N-60	meadow - north edge	1	0	0	0	0	0	0	0
8N-60	meadow - north edge	2	3	0	0	0	0	0	3
8N-60	meadow - north edge	3	5	0	0	0	0	0	5
8N-60	meadow - north edge	4	3	0	0	0	0	0	3
8N-60	meadow - north edge	5	0	1	0	0	0	0	1
8N-60	meadow - north edge	6	0	0	0	0	0	0	0
8N-120	woodland	1	0	0	0	0	0	0	0
8N-120	woodland	2	1	0	0	0	0	0	1
8N-120	woodland	3	17	0	1	0	0	0	18
8N-120	woodland	4	6	0	0	0	0	0	6
8N-120	woodland	5	1	0	0	0	0	0	1
8N-120	woodland	6	0	1	0	0	0	0	1
8N-240	woodland	1	0	0	0	0	0	0	0
8N-240	woodland	2	12	0	21	0	0	0	33
8N-240	woodland	3	27	0	6	0	0	0	33
8N-240	woodland	4	1	0	0	0	0	0	1
8N-240	woodland	5	0	1	0	0	0	0	1
8N-240	woodland	6	0	0	0	0	0	0	0
8N-360	woodland	1	0	0	0	0	0	0	0

Transect	Community Type	Size Class	PSME	PIPO	CADE	QUGA	ABGR	PILA	TOTAL
8N-360	woodland	2	10	0	17	0	0	0	27
8N-360	woodland	3	9	1	4	0	0	0	14
8N-360	woodland	4	4	0	1	0	0	0	5
8N-360	woodland	5	0	0	0	0	0	0	0
8N-360	woodland	6	1	0	0	0	0	0	1
285	transition	1	0	0	0	0	0	0	0
285	transition	2	11	0	9	0	0	0	20
285	transition	3	13	0	12	0	0	0	25
285	transition	4	5	0	2	0	0	0	7
285	transition	5	1	0	0	0	0	0	1
285	transition	6	0	0	0	0	0	0	0
286	transition	1	0	0	0	0	0	0	0
286	transition	2	4	6	1	4	0	0	15
286	transition	3	13	5	0	2	1	0	21
286	transition	4	7	1	1	0	0	0	9
286	transition	5	0	3	0	0	0	0	3
286	transition	6	0	0	0	0	0	0	0
288	transition	1	8	0	0	0	0	0	8
288	transition	2	20	1	0	0	0	0	21
288	transition	3	7	1	0	0	0	0	8
288	transition	4	9	0	1	0	0	0	10
288	transition	5	3	0	0	0	0	0	2
288	transition	6	0	2	0	0	0	0	2
290	transition	1	0	0	0	0	0	0	0
290	transition	2	13	0	1	0	0	0	14
290	transition	3	25	0	0	0	0	0	25
290	transition	4	7	1	0	1	0	0	9
290	transition	5	1	0	0	0	0	0	1
290	transition	6	0	0	0	0	0	0	0
293	transition	1	0	0	0	0	0	0	0
293	transition	2	9	0	1	27	0	0	37
293	transition	3	9	0	3	1	0	0	13
293	transition	4	6	0	3	0	0	0	9
293	transition	5	0	0	0	0	0	0	0
293	transition	6	0	0	0	0	0	0	0
295	transition	1	12	0	2	0	0	0	14
295	transition	2	24	3	0	3	1	0	31
295	transition	3	6	0	0	3	0	0	9
295	transition	4	8	0	0	0	0	0	8
295	transition	5	1	1	0	0	0	0	1
295	transition	6	1	0	0	0	0	0	1
299	transition	1	18	2	0	0	0	0	20
299	transition	2	8	4	0	20	0	0	32
299	transition	3	7	7	0	4	0	0	18
299	transition	4	2	1	0	0	0	0	3
299	transition	5	0	0	0	0	0	0	0
299	transition	6	0	0	0	0	0	0	0

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