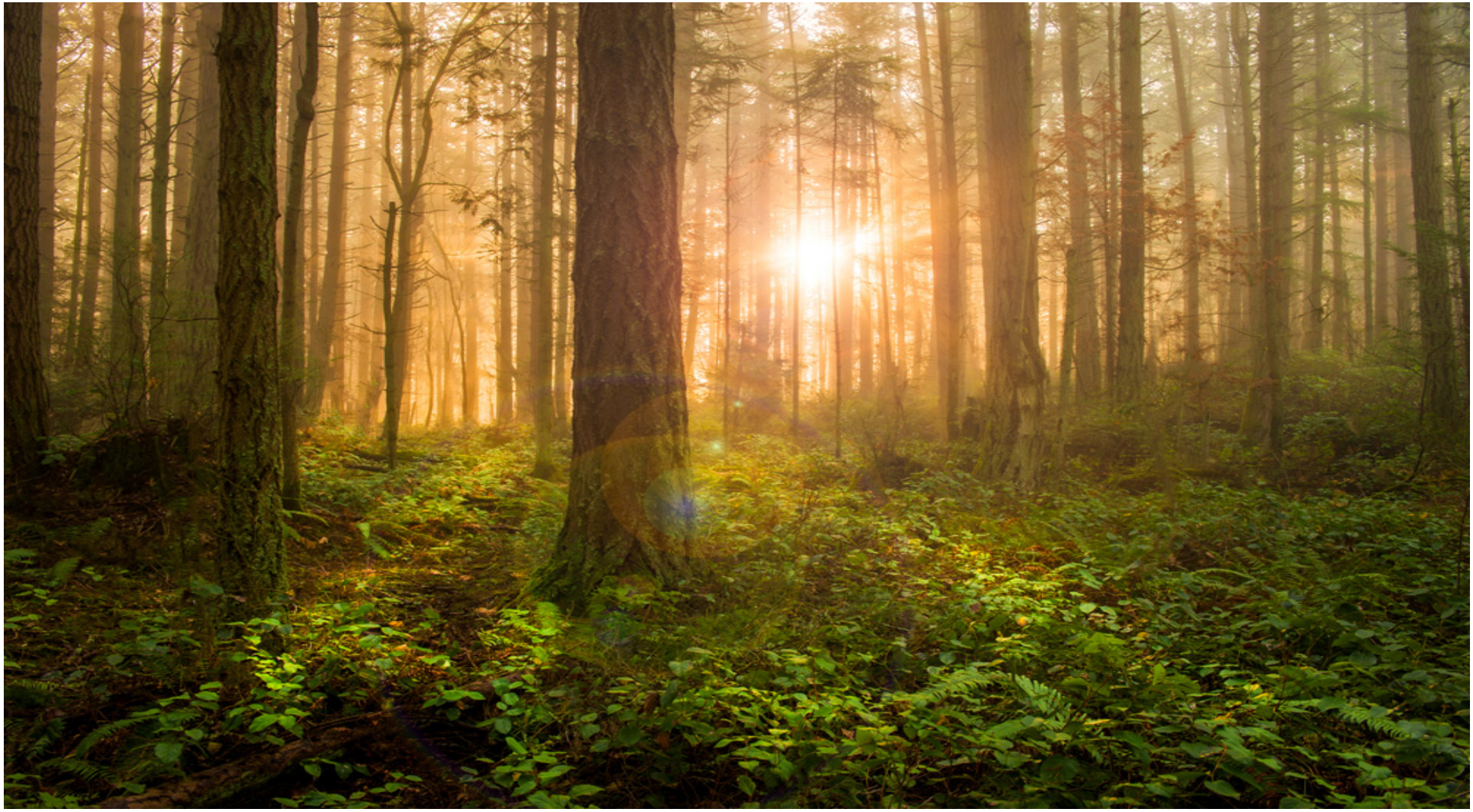

Photo by Edmund Lowe Photography

Lummi Island Heritage Trust
Otto Preserve Forest Inventory
2019-2020

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Acknowledgments

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Acknowledgments

This forest inventory could not have been undertaken without the diligent work of dedicated volunteers. For their skills, enthusiasm, energy, and generous contributions of their time, we wish to thank Bianca Scott and Sam Kaiser, Western Washington University interns; Judy Bush and Kathy Zaiser, both of Lummi Island, and Wanda Cucinotta, Lummi Island Heritage Trust Stewardship Coordinator. Thanks also go to Alison Hitchcock, retired Department of Natural Resources forester who helped review this document.

The Preserve's story begins with the Lhaq'temish or the Lummi People, who are the original inhabitants of Washington's northernmost coast and southern British Columbia. Being the original fishers, hunters, gatherers, and harvesters of Lummi Island's abundance, for thousands of years they worked, struggled and celebrated life on these shores. The Lummi People see their homeland as a place to enjoy an abundant, safe, and healthy life in mind, body, society, environment, space, time and spirituality – aligning well with the aspirations of the Lummi Island Heritage Trust.

Inventory Project Summary

The Otto Preserve is one of four preserves owned and managed by the Lummi Island Heritage Trust (LIHT). The Preserve is composed of several parcels on Lummi Island (North Puget Sound, Washington) purchased at separate times over the past 21 years, totaling 104 acres, of which 98 acres are forested. Preserve forests occur on flat to rolling terrain, and range from drier upland forests with shallow rocky soils and occasional steep rocky slopes, to productive lowland forests with deeper moist soils, to wooded wetlands. Most areas were initially logged via clearcutting, removing nearly all old growth trees around the late 1800s to 1900, with forests naturally regenerating to native species. Once the second growth trees were large enough, some regenerated forests were periodically selectively logged by the former owners, who used the land largely for wood production, farming, and grazing. Several small areas of second growth forest were clearcut in the 1980s and around 1990, and replanted, largely to Douglas fir. All forest stands are predominantly even-aged, with an overstory dominated by Douglas fir, except for the Mixed Conifer/Deciduous stand, and to a lesser extent the Lowland Douglas Fir stand, both of which have a greater diversity of ages and species.

During the summer and fall of 2019 interns, volunteers, and staff conducted the first forest inventory of the Trust’s Otto Preserve. Our purpose was to assess species composition and diversity, forest structure, tree age and size distribution, and health of both overstory and understory vegetation. To improve sampling accuracy, we conducted extensive pre-inventory field reconnaissance to divide the Preserve by forest characteristics, which were then geospatially mapped. Forest stand structure and species composition varied considerably between stands. We measured 697 trees and counted 2,076 shrubs, saplings, and seedlings in 65 variable radius and an equal number of fixed radius plots within the Preserve. These plot data were used to estimate stand and forest metrics such as canopy and understory species and age diversity, health, biomass, carbon storage and sequestration amounts and rates. Current and projected biomass volume and carbon sequestration by trees were important outputs of this project, as was an attempt to assess the forest’s health and resilience to climate change.

Some stands were found to be overstocked, but relatively healthy and diverse, with recent indications of drought stress and mortality, and in some areas, a limited presence of damaging insect and diseases, such as root rot. Diameter growth rates over the past 5 years in the clearcut stands are quite low, likely due to competition of the closely spaced trees for water and other resources. The Lowland Douglas Fir stand is beginning to transition to incipient old growth conditions, or in forestry terms, understory re-initiation, characterized by larger, more widely spaced overstory trees, increased tree diversity of shade tolerant trees, and greater volumes of downed woody debris. This process will continue across the Otto

Preserve for the next several hundred years until old growth conditions prevail, unless major disturbance events occur. The risk of catastrophic, stand-replacing wildfire is low, with major fire return intervals in Western Washington ranging from 200 and 1,000 years. Forest fuels reduction operations such as thinning or prescribed burning are generally ineffective in this productive forest type due to the rapid regrowth and accumulation of woody biomass. Fires that do occur will likely be low intensity ground fires.

Climate change may already be having some impacts on the forest, with increased mortality of western red cedar saplings observed, presumably due to recent drought, especially on the thinner soils and in denser stands. Mean monthly temperatures for Lummi Island have increased 1.82 degrees F. between 1895 and 2020 (PRISM http://www.prism.oregonstate.edu/). Other impacts of warmer temperatures and especially warmer winters and nights may be having subtler but more profound impacts by reducing starch reserves in trees, weakening them, and reducing their resistance and increasing susceptibility to insect and disease attacks. Higher temperatures can exacerbate drought stress, and drier forest organic materials will increase wildfire risk during the dry season.

The table below summarizes overall inventory findings. Note that stand and forest scale metrics are estimates derived from the sampling procedures. We discuss each stand in greater detail later in this report.

Otto Preserve Inventory – Overstory Summary Data

Total number of trees sampled	697 in 65 survey plots
Total number of trees	17,508
Average number of live trees per acre	194
Total # of dead trees (snags)	1,747
Average live biomass per acre	460,100 lbs (230 tons/acre)
Total forest biomass in standing trees	45,211,520 lbs (22,606 tons)
Carbon Storage	
Total carbon stored	22,605,760 lbs (11,303 tons)
Additional carbon storage/year	636,192 lbs/year (318 tons/year)
Daily carbon storage by trees	1,743 lbs/day (0.87 tons/day)
CO2 Uptake	
Annual CO2 uptake by all trees	2,331,127 lbs (1,166 tons)
Annual CO2 uptake/acre	23,720 lbs/acre (11.86 tons/acre)
Daily CO2 uptake by all trees	6,386 lbs/day (3.2 tons/day)
Annual oxygen release by trees	1,694,934 lbs/year (847 tons/year)
Annual oxygen release per acre	17,295 lbs/acre/year (8.6 tons/acre/year)
Average daily oxygen release by trees	4,644 lbs/day (2.3 tons/day)

Introduction

The mission of the LIHT is to create a legacy of abundant open space, native habitat, and natural resources on Lummi Island by inspiring people to protect and care for the island's farms, forests, wetlands and shorelines forever. LIHT plays a crucial role in preventing conversion of lands to development, restoring damaged lands, improving connected landscapes to help wildlife, plants and fish adapt to a changing climate, protecting water quality and aquifer recharge capacity, and implementing management practices to increase carbon sequestration in forests, wetlands, soils, and grasslands.

The Otto Preserve, one of four Preserves owned and managed by the Trust, encompasses 104 acres of forest, meadow, and wetlands. It is surrounded by several properties that are in conservation status and are protected from further development. The original 70 acres of the Preserve was purchased in 1999 and additional acreage has been added over the years, all of which are protected from development in perpetuity by the Trust.

During the spring and summer of 2019, interns, volunteers, and staff conducted the first forest inventory of the Lummi Island Heritage Trust's Otto Preserve on Lummi Island in North Puget Sound, Washington. Our purpose was to assess species composition and diversity, tree age and size distribution, and health in both overstory and understory vegetation. Current and projected biomass volume and carbon sequestration by trees were important outputs of this project, as was assessing the forest's resilience to climate change. These findings will be used to guide future management of the Preserve's forest resources.

Methods

In general, Otto Preserve forests occur on flat to rolling terrain, ranging from somewhat droughty uplands with shallow rocky soils and occasional steep rocky slopes, to productive lowland forests with deeper moist soils, to wooded wetlands. Forest stand structure and species composition vary considerably between stands.

Forest Stand Delineation

To improve sampling accuracy, we conducted extensive pre-inventory field reconnaissance to divide the Preserve by forest characteristics, based on species composition, structure and tree size, into six relatively uniform "stands": Upland Douglas Fir; Lowland Douglas Fir; Mixed Conifer/Deciduous. Additionally, three clearcut areas, replanted in the 1980 and 1990s were delineated as separate stands (Figure 5, Appendix B). Forest stands were then mapped using existing aerial photography and digitized for GIS (Geographic Information System) attributes.

Sampling Procedures and Metrics

To characterize the forest overstory, we measured 697 trees in 65 randomly distributed variable radius plots, using 20 or 40 Basal Area Factor (BAF) wedge prisms (using only one BAF prism on a plot) and located along compass bearing lines laid out within the Preserve. Tree measurements included Diameter at Breast Height (DBH) and species. The condition of trees in each plot were evaluated as to whether they were living, dead, dominant or co-dominant, and condition.

Tree Height Samples and D.B.H. Statistics

The height and DBH of 40 randomly selected dominant or co-dominant trees was measured using an electronic clinometer and a diameter tape, and tree ages were determined by using an increment corer, coring 22 randomly selected trees with at least one tree from each stand. These data enabled us to statistically link DBH and height, and provided a basis for estimating height distributions for the six stands in the Preserve. The Weibull Probability Distribution is commonly used to characterize forest DBH versus height. A regression was performed using the R statistical library, ForestFit (Teimouri, 2019). Figure 1 is a graph derived from the resulting fit displaying the estimated distribution of tree heights in two Otto Preserve stands for Douglas fir, the predominant species, given the DBH distribution for those stands.

Number of Trees/Acre

The estimated number of trees per acre (TPA) for a given tree species and DBH was determined by dividing the BAF by the basal area per tree tallied (in square feet) (Zobrist et al). Individual TPA data were summed per plot to arrive at total TPA/plot. These sample plot data were expanded to each stand, then stand data were consolidated to generate Preserve-level findings.

Site Index (Productivity)

Site index, a measure of basic site productivity, was determined by using average stand tree height and age, and published site index graphs for Western Washington tree species (DeYoung, 2016).

Understory Composition

To determine the understory composition, diversity, and health, each variable radius plot included a 20-foot fixed radius plot where all shrubs and small trees were counted by species. The percent groundcover was estimated and any uncommon or interesting flora was noted. The average number of shrubs, seedlings, and saplings were counted within the plots and multiplied by 34.67, which is the number of 20-foot radius plots (with an area of 1,256 square feet/plot) per acre.

Live Tree Biomass

Using acquired tree measurement data and existing research-based formulas and established procedures, we calculated total biomass per stand by species and overall carbon sequestration amounts and rates. The primary metric for tree biomass surveys is DBH. A secondary metric in many studies is tree height. DBH measurement is easily done, but height measurement requires a view of the tree top from a distance on the ground roughly equal to the height. Because views of tree tops were only occasionally available in the Otto Preserve, formulas were selected from tree biomass studies that did not require height measurements for biomass estimation.

Criteria for choice of calculation method included consideration of the number of trees on which formulas were based, the regional and climate proximity, species specificity, and inclusion of bark, branches, roots, and foliage. Statistical measures of the methods used to derive formulas from field measurements were evaluated to ensure reliability of the formulas used.

Formulas were selected from a study by the Oregon State University School of Forestry (Gholz et al., 1979), from a study published in *Forest Science* (Jenkins et al., 2003), and supplemented with root biomass calculations published by the Forestry Contracting Association in the United Kingdom (McKay et al., 2003, Teimouri, 2019).

Live Tree Biomass Change

Twenty-five ring core samples were taken to estimate tree diameter growth rates. Ring widths were measured and tabulated using a digital microscope and GIMP image processing software (GIMP Team, 2019). Cores that extended well beyond tree centers were split into two separate ring width sequences. A tree diameter growth rate estimation procedure was developed based on generalized ring width trends using the dendrochronology software package dplR (Bunn et al., 2019) written in R (R Core Team, 2019), a statistical software library. Following methods presented in the classic dendrochronology text, Tree Rings and Climate (Fritts, 1976), estimates for three parameters, a, b, and c in the exponential formula $f(t) = ae^{-bt} + c$ were made using a regression method in the dplR package wherein a curve was fitted to tree ring width sequences grouped by species, one set of parameters for each species. Finally, estimated bark thickness (Larsen and Hann, 1985) was added to inside-bark growth rates derived from the exponential formula yielding DBH growth rates.

Biomass accumulation was estimated by calculating present biomass using DBH and subtracting that from the same calculation using DBH incremented by one year using the DBH growth rates described above. All results represent dry wood biomass. The commonly accepted metric of 50% percent carbon content for dry wood biomass was used in all estimates (Matthews, 1993). The process of carbon uptake by CO_2 capture also produces oxygen. The ratio of the molecular weight of two oxygen atoms to the molecular weight of carbon is 2.6642, which means that for every ton of carbon sequestered in standing trees in the Otto Preserve, 2.6642 tons of oxygen are released.

Overall Inventory Results

Most forested areas in the Preserve were initially logged via clearcutting in the late 1800s to 1900, removing all or nearly all old growth trees, with forests naturally regenerating to native species. Evidence of large-scale fires that occurred in old growth logging slash, which included burned stumps and charcoal in the soil, was observed over the entire Preserve. Once the second growth trees were large enough, some regenerated forests were periodically selectively logged by former owners, who used the land largely for wood production, farming and grazing. Several small areas of second growth forest were clearcut in the 1980s and around 1990, and replanted, predominantly to Douglas fir. All forest stands are largely even-aged. The overstory is dominated by Douglas fir, except in the Mixed Conifer Deciduous stand, and to some extent the Lowland Douglas Fir stand, which have a greater diversity of tree ages and species.

While site productivity varied somewhat between stands, most of the lands in the Preserve are moderately productive (Class III or IV for Douglas fir), using a metric called “site index” that uses tree age and height (Appendix, Table 5) (DeYoung, 2016) to assess site quality. Most forested lands in the North Puget Sound area fall into these site classes.

Preserve forests were found to be relatively healthy, but with recent indications of drought stress and mortality especially in the Upland Douglas Fir stand, where tree stocking (density) is high and competition for water, light and nutrients is intense. All stands across the Preserve are overly dense or overstocked, with trees throughout experiencing competition for resources and growing relatively slowly over the past 5 years. In some areas, a limited presence of damaging insect and diseases were observed. Regeneration of western red cedar is nearly completely lacking, presumably

due to heavy deer browsing as no cedar seedlings were recorded in plots, and the few that were seen outside of plots were heavily browsed. This paucity of cedar regeneration will alter the future forest, with a major component of west side old growth forest being underrepresented or missing, unless supplemental plantings are implemented. Only a few Sitka spruce and Pacific yew trees were found. Low populations of all three of these species could be augmented by planting seedlings and protecting them from deer.

There has been some concern regarding the perceived risk of catastrophic wildland fire in the Preserve. We consulted with several fire operations, forest management, and fire ecology experts from the Washington Department of Natural Resources (WADNR) and Washington State University (WSU) to determine the risk of stand replacing wildfires in the Preserve. According to these specialists, while fire is a natural part of our forests, the risk of catastrophic wildfire is minimal. Stand replacing (crown) fires in west side Puget Sound lowland forests are quite rare, with major fire return intervals ranging from 200 to 1,000 years (personal communications: Tom Smith, David Way, and Matt Provencher (WADNR) and Dr. Crystal Raymond (University of Washington Climate Impacts Group, 2020). The last occurrence of large-scale crown fires not associated with logging occurred in 1701 in western Washington and the Olympic Peninsula. Fires that generally occur in intact west side forests are nearly always ground fires, with occasional torching of individual trees. Given that nearly all wildfires in this region are human caused, the heavy recreational use of Otto Preserve increases the risk of fire occurrence. Such human-induced risk could be substantially reduced by closing the Preserve during extreme fire danger conditions. Climate change may exacerbate these conditions and increase risk further in the future, creating more days of extreme fire danger. Unless and until climate change radically alters our current climate, wildfires that do occur will likely be small, relatively low-intensity ground fires. Fuels reduction operations such as thinning are not effective in this forest type, as the Preserve's very productive forests rapidly rebuild forest fuel loads (Personal communication, Dr. Crystal Raymond, 2020). Given the low risk of catastrophic wildfire, and the ineffectiveness of thinning, there is little rationale for investing in forest fuels reduction or other wildfire risk mitigation interventions in the Preserve, other than closures during high danger periods.

The Lowland Douglas Fir stand is several decades older than surrounding stands and is beginning to transition to early old growth conditions, currently characterized by larger, more widely-spaced overstory trees, increased tree diversity of shade tolerant trees (western red cedar, western hemlock and grand fir) in the understory, and some downed woody debris. Unless major disturbance events occur (such as catastrophic stand replacing wildfire, or more likely a major windthrow event), this process will continue for the next several hundred years in all stands until old growth conditions dominate.

Climate change may already be having some impacts on the forest, with increased mortality of western red cedar saplings due to recent drought, especially on the less productive soils in the Upland Douglas Fir stand. Mean monthly temperatures for Lummi Island have increased 1.82 degrees F. between 1895 and 2020 (PRISM http://www.prism.oregonstate.edu/). Warming is expected to continue, with an accelerated rate of warming predicted after 2050. Other impacts of warmer temperatures and especially warmer winters and nights may be having subtler but more profound impacts by reducing starch (energy) reserves, subsequently weakening trees and reducing their resistance to insect and disease attacks. Some species are considered more sensitive to changes in climate, including western red cedar and western hemlock. Douglas fir and grand fir may be better suited to warmer and drier conditions. Higher temperatures can exacerbate drought stress, increase tree and shrub mortality, and dry out forest organic materials - increasing wildfire risk. Because of the uncertainty of impacts on the Preserve brought about by climate change, a primary goal should be to increase overall resilience to a changing climate by enhancing species and age diversity, reducing competition-induced drought stress by reducing stand density, removing invasives, and monitoring for and maintaining overall tree and forest health. Future interventions may include intentionally planting under-represented tree and shrub species that are native to Puget Sound and are better adapted to conditions expected to develop over the next century, as well as species and ecotypes from locations in southern Washington and Oregon, which would presumably be better adapted to

hotter, drier conditions (known as “assisted migration”). Openings created by disturbances for example, from windthrow, could be viewed as opportunities to test other species better adapted to expected future conditions, and to improve resilience by increasing species diversity.

Tree Biomass and Carbon Estimates

Live trees per acre and stand biomass per acre per DBH range are illustrated in Figures 2 and 4 in Appendix B. Total carbon dioxide uptake estimate for the entire Otto Preserve was 6,387 pounds per day, sequestering about 1,743 pounds of carbon and releasing approximately 4,644 pounds of oxygen[1]/day to the atmosphere. Douglas fir trees comprise 51% of the total number of trees, but due to their larger size and height, store 81% of the biomass and thus, carbon. Western red cedar is the next most common tree, storing 7.7% of the biomass. Birch, alder and bigleaf maple each comprise between 7% and 9% of the Preserve’s trees but store much less biomass than fir or cedar. Overall the Preserve’s biomass storage in live trees is nearly 41 million pounds, half of which is carbon storage. Based on measured growth rates, trees in the Preserve will sequester an additional 636,192 pounds of carbon/year, or more than 1,743 pounds/day (not accounting for tree mortality). Significant but undetermined amounts of additional carbon is stored and/or sequestered in the extensive shrub layer, and as organic matter in the soil.

Inventory Results and Management Recommendations by Stand

We inventoried 65 plots distributed among six separate stands that were each characterized as one of four stand types: Upland Douglas Fir, Lowland Douglas Fir, Clear Cut, Mixed Conifer and Deciduous. Table 1 in Appendix A covers forest metric highlights by stands. Table 2 in Appendix A lists the number of trees per stand by species for the Preserve. Table 4 lists the number of shrubs, seedlings, saplings, and selected invasive plants in each stand. Table 5 is a Site Index table based on Douglas Fir average height per stand. Figures 5 and 6 in Appendix B are maps of the Otto Preserve showing the locations of the six stands and plot locations recorded with a GPS.

The number and biomass of trees per acre, by species and DBH are detailed in Tables 6, 7 and 8 in Appendix A. Figures 2, 3, and 4 in Appendix B are graphic representations of data from Appendix A.

Upland Douglas Fir

The Upland Douglas Fir stand is the uphill area roughly within the area bounded by the Main Loop Trail, as well as portions of the Baumgart Woods addition on the north end of the Preserve (Figure 5). The stand is an even-aged forest, composed largely of Douglas fir, with an average age of 85 years. Upland soils appear to be shallow, stony and less productive than soils in lower portions of the preserve. As a result, tree diameter, height, and diameter growth rates are less than found in other stands (Table 6a). Tree species diversity is low, and trees are relatively closely spaced, with an average basal area (BA)/acre (a measure of competition among trees in a stand, or “stocking”) of 227 sq. ft/acre, which indicates overstocking and fairly intense competition. Understory development with the emergence of other shade tolerant tree species is less than found in other stands. The stand is slowly self-thinning, with a significant average number (32) of snags/acre and suppressed trees, which are beginning to create openings, which will allow more light in the understory, add more downed woody debris, and eventually encourage more regeneration of shade-tolerant tree species such as western red cedar and grand fir. This stand was the only one showing signs of drought stress, with numerous western red cedar

[1] based on the photosynthesis reaction of: $6CO_2 + 12H_2O + \text{light energy} = C_6H_{12}O_6 + 6O_2 + 6H_2O$

saplings either dead or dying back. Evidence of root rot on Douglas fir was found in at least one small location in this stand. There is little evidence of second growth tree removal (selective logging) in this stand.

Douglas fir contains nearly all (98%) of the total biomass in this stand, storing nearly 14 million pounds, or about 7 million pounds of carbon. On a per acre basis, biomass/acre for all species is more than 472,000 pounds, a substantial volume. Annual accumulation of additional biomass, based on current growth rates is 19,129 pounds/, or 9,565 pounds of carbon.

Management actions that would increase structural and species diversity include planting underrepresented species seedlings in any openings, and then caging them from deer. To create conditions that enhance seedling survival, several overstory Douglas fir trees/acre should be girdled (away from trails to avoid hazards to users). This would 1) create openings in the crown, allowing more light to reach the forest floor, 2) reduce competition among remaining live trees, reducing stress and improving tree and forest health, and 3) increase the number of snags, enhancing woodpecker, owl and cavity nesting songbird habitat. Nest boxes for flying squirrels could be installed to increase their populations. Invasive plants such as holly and Herb Robert were found to be present throughout the stand. Eradication and control should focus first on holly, as that species will be easier to control, then perhaps shift to Herb Robert, which is commonly found along trails and in several locations on the Baumgart addition. Herb Robert will be much more difficult to manage and/or control due to its current extent and long-lived seeds.

Data from the understory inventory are in Appendix A, Table 4.

Lowland Douglas Fir

The Lowland Douglas Fir stand is located along the base of the steep hill in the center of the Preserve, winding around from the north end of the hill to the southeastern end (Figure 5). Soils are deeper, moister and somewhat more productive. Being 25 years older than the Upland Douglas Fir stand and with better growing conditions, the trees, which are largely Douglas fir, but with a significant component of grand fir, western hemlock and western red cedar, are larger and taller, and more widely spaced than in the Upland Douglas Fir stand (Table 6b). Average stand age is approximately 110 years. Average Basal Area/acre is 340 sq. ft/acre, which is quite large and far exceeds the other stands in the Preserve, an indication of many large trees, and competition between trees. This lowland stand also has more downed woody debris, a denser shrub layer, and a denser sapling understory composed of shade-tolerant conifers. There is a total of 104 snags in this stand, or 9 snags/acre. The largest diameter Douglas fir (~51” DBH) and the tallest tree (197’) on the Preserve (also a Douglas fir) are found in this stand. The stand appears healthy, with few pests or diseases observed (other than Hemlock Woolly Adelgid on western hemlock, which according to WADNR foresters does not seem to be a serious pest in the Pacific Northwest). Some larger second growth trees were selectively harvested over the years, as evidenced by large stumps scattered through the stand. Evidence of past trauma to the lower boles of many trees on the south end of this stand (as indicated by swollen basal portions of the trunks) are evidence of either past grazing and/or fire and logging damage. With its greater diversity, large tree size, developing shade-tolerant understory and large amounts of downed woody debris, this stand is further along in transitioning to old growth structure and characteristics.

Douglas fir contains 91% of the total biomass in this stand, storing nearly 14 million pounds, or about 7 million pounds of carbon. On a per acre basis, total biomass/acre for all species is 841,000 pounds, a very high accumulated volume due to the large size and height of the trees. The second largest source of total biomass/stand is big leaf maple, with 782,000 pounds or around 5% of the stand total. Annual accumulation of additional biomass, based on current growth rates, is 22,326 pounds, or 11,163 pounds of carbon storied/year.

Management actions that would increase structural and species diversity include planting underrepresented species seedlings, and then caging them from deer. To create conditions that enhance seedling survival, several overstory Douglas fir trees/acre should be girdled (away from trails to avoid hazards to users). This would 1) create openings in the crown, allowing more light to reach the forest floor, 2) reduce competition among remaining live trees, reducing stress and improving tree and forest health, and 3) increase the number of snags, enhancing woodpecker, owl and cavity nesting songbird habitat. Nest boxes for flying squirrels could be installed to increase their populations. Other management activities include monitoring for hazard trees, and removal of invasive plant species such as holly and Herb Robert.

Data from the understory inventory are in Appendix A, Table 4.

Mixed Conifer and Deciduous

The Mixed Conifer and Deciduous stand is located largely to the west of the west portion of the Main Loop Trail, grading into the wetland on the west side of the property and extending north into the Baumgart Woods addition. It bisects and comprises much of the lower, somewhat wetter area served by Betty's Shortcut trail. Soils range from moist to poorly drained depending on micro-elevations (Figure 5). Second growth trees in the area have been selectively harvested over the years. The land was grazed, as evidenced by barbed wire running through the forest, and selectively logged. The forest in this stand has the greatest species diversity on the Preserve, with larger numbers of deciduous tree species, large western red cedar, hemlock and grand fir with a few specimens of Sitka spruce and Pacific yew. There is an average of 6 snags/acre. Stand data can be found in Table 1 and Table 6c. The largest diameter western red cedar (72") and big leaf maple (66") trees are found in this stand, though their unusually large size is not representative of the rest of the stand. Forest structure shows a range of age classes, with abundant regeneration of sapling size western red cedar, grand fir, and western hemlock, and in areas near the few occurring Sitka spruce (no western red cedar seedlings were found). No serious evidence of insect or disease damage was found, though this area has the highest concentration of invasive holly.

Douglas fir contains 41% of the total biomass in this stand, storing more than 10 million pounds, or about 5 million pounds of carbon. On a per acre basis, total biomass/acre for all species is more than 251,000 pounds. The second largest source of total biomass in this stand is cedar, with more than 2.4 million pounds, or around 24% of the stand total. Grand fir and big leaf maple each store nearly 1.2 million pounds of biomass or 12% each. Annual accumulation of additional biomass, based on current growth rates is 19,165 pounds, or 9,583 pounds of carbon.

Management actions that would increase structural and species diversity include planting underrepresented species seedlings, and then caging them from deer. To create conditions that enhance seedling survival, several overstory trees/acre of various species, particularly alder, should be girdled (away from trails to avoid hazards to users). This would 1) create openings in the crown, allowing more light to reach the forest floor, 2) reduce competition among remaining live trees, reducing stress and improving tree and forest health, and 3) increase the number of snags, enhancing woodpecker, owl and cavity nesting songbird habitat. Nest boxes for flying squirrels could be installed to increase their populations. Holly populations are the highest in this stand, with several female trees and many small trees, shrubs and seedlings/sprouts growing throughout the stand. Eradication and control should start with female tree eradication across the preserve. Once control measures are completed in the other forest stands, eradication efforts should focus on this stand.

Data from the understory inventory are in Appendix A, Table 4.

East Clearcut

Second growth timber in this small area was harvested in 1990 and replanted on a close spacing to Douglas fir shortly thereafter. Stand data can be found in Table 1 and 6d. Average tree age in this even-aged stand is 30 years. The area is self-thinning, with an average of 137 small dead snags/acre, as well as numerous suppressed trees. Evidence of blackberry invasion after harvesting is still present in some areas with mostly dead blackberry canes winding up trees or forming dense thickets. The understory has few plants growing under the dense overstory. This stand should have been thinned some years ago, as evidenced by dead trees succumbing to competition-induced stress. Competition for resources among existing live trees is very intense, reducing the overall growth rate of individual trees, increasing individual tree physiological stress, and reducing health and vigor.

This stand stores a total of about 370,000 pounds of biomass (169,000 lbs/acre), or 185,000 pounds of carbon, 85% of which is stored by Douglas fir trees. Cedar and alder store a smaller amount of biomass (around 28,000 pounds each).

While the stand already has a large number of snags, they are relatively small and not of high value to wildlife. Management options could include girdling some of the larger intermediate crown class trees to further thin the stand and allow more light to reach the forest floor, stimulating herbaceous and shrub growth and plant diversity. The girdled dead standing trees will increase the number of snags, enhancing woodpecker, owl and cavity nesting songbird habitat. Removal of any invasive plants is also recommended.

Data from the understory inventory are in Appendix A, Table 4.

South Clearcut

Second growth timber in this relatively small area was harvested in the 1980s and replanted to Douglas fir sometime thereafter. Stand data can be found in Table 1 and 6e. Average tree age in this even-aged stand is approximately 30 to 40 years. The area must have been planted to seedlings on a wider spacing, as there were no snags detected within our plots, indicating that there has not been much self-thinning or mortality. Evidence of blackberry invasion after harvesting is still present with mostly dead (and a few live) blackberry canes winding up trees or forming dense thickets. Holly is also present and requires control. A few overstory trees could be girdled to reduce competition between remaining trees and enhancing habitat. Invasive plant removals are also recommended.

Due to lower densities, small area, and smaller size of the trees, this stand stores a total of only 33,000 pounds of biomass (24,000 lbs/acre), or 16,500 pounds of carbon, 94% of which is stored by Douglas fir. Cedar and alder store the remaining amount of biomass (around 2,000 pounds total).

Data from the understory inventory are in Appendix A, Table 4.

West Clearcut

Second growth timber in this area was harvested in 1990 and replanted on a close spacing to Douglas fir shortly thereafter. Stand data can be found in Table 1 and 6e. The area is self-thinning, with a large number of dead snags (average of 57/acre) and suppressed trees. Evidence of blackberry invasion after harvesting is still present in some areas with mostly dead blackberry canes winding up trees or forming dense thickets.

Understory plants are nearly absent due to little light penetrating the dense overstory. This stand should have been thinned some years ago, as evidenced by a larger number of dead trees. Many more are suppressed and will eventually die.

This stand stores a total of more than 700,000 pounds of biomass (197,000 lbs/acre), or 350,000 pounds of carbon, 84% of which is stored by Douglas fir. Grand fir, big leaf maple, alder and other species store the remainder amount of biomass (about 115,000 pounds).

Management options could include girdling a number of intermediate and poorly formed co-dominant crown class trees to thin the stand and allow more light to reach the forest floor, stimulating herbaceous and shrub growth and increased stand biodiversity. While the stand already has a relatively large number of snags, they are generally small and not of high value to wildlife. The girdled dead standing trees will increase the number of snags, enhancing woodpecker, owl and cavity nesting songbird habitat. Removal of any invasive plants is also recommended.

Data from the understory inventory are in Appendix A, Table 4.

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Appendices

Appendix A - Tables
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Otto Preserve Forest Stands showing Inventory Plot Locations

APPENDIX A: TABLES

Table 1. FOREST METRICS HIGHLIGHTS BY STAND							
METRIC	**LOWLAND DOUGLAS FIR**	**UPLAND DOUGLAS FIR**	**MIXED CONIFER**	**CLEARCUT EAST**	**CLEARCUT SOUTH**	**CLEARCUT WEST**	**OTTO FOREST**
Average Basal Area	340	227	227	120	187	156	**232**
Avg. DBH (in)	31	20	22	10	9	10	**20.5**
Avg. # trees/acre	119	169	172	290	207	385	**198**
Forest Stand acreage	18.3	30.0	40.4	2.2	1.4	3.6	**95.8**
Total # trees/stand	2,171	5,056	6,954	633	288	1,385	**16,488**
Total Biomass/stand (LBS)	15,373,377	14,165,802	10,142,903	369,148	33,091	709,602	**40,793,922**
Avg. Biomass/acre (LBS)	840,994	472,508	251,249	169,334	23,807	197,112	**425,824**
Total Carbon Sequestered/stand (LBS)	7,686,688	7,082,901	5,071,451	184,574	16,546	354,801	**20,396,961**
Avg. Carbon Sequestered/ac. (LBS)	420,497	236,254	125,624	84,667	11,903	98,556	**212,912**
Total # Snags	104	681	131	548	0	283	**1746**
Avg. # Snags/acre	9	32	6	137	0	57	**18**
Total # Trees Measured	108	272	220	31	28	40	**699**
Total # Plots Measured	11	21	21	4	3	5	**65**
Avg. 5-yr Growth (in)	0.137 (7 trees)	0.118 (3 trees)	0.190 (6 trees)	0.992 (4 trees)	0.324 (1 tree)	0.241 (1 tree)	0.171 (22 trees)
Avg-5 yr Biomass Accumulation (LBS)	22,326	19,129	19,165	30,277	21,424	19,913	133,234

Table 2. NUMBER OF TREES/STAND BY SPECIES									
STAND	**DOUGLAS FIR**	**GRAND FIR**	**CEDAR**	**HEMLOCK**	**SPRUCE**	**BIGLEAF MAPLE**	**ALDER**	**OTHER**	**BIRCH**
Lowland DF	1,563	24	48	0	0	537	0	0	0
Upland DF	4,788	0	145	0	0	122	0	0	0
Mixed Conifer and Deciduous	1,157	650	1,005	241	5	585	1,123	735	1,453
Clearcut East	414	0	45	0	0	0	174	0	0
Clearcut South	169	0	18	0	0	0	101	0	0
Clearcut West	796	53	0	0	0	33	70	433	0
Total Number Trees/Preserve by Species	**8,887**	**727**	**1,261**	**241**	**5**	**1,278**	**1,468**	**1,169**	**1,453**
Average Number Trees/Acre by Species	93	8	13	3	0	13	15	12	15
Percent of Total # Trees/Stand by Species	53.9%	4.4%	7.6%	1.5%	0.03%	7.7%	8.9%	7.1%	8.8%

Table 3. TOTAL OVERSTORY BIOMASS/STAND BY SPECIES (LBS)										
STAND	**DOUGLAS FIR**	**GRAND FIR**	**CEDAR**	**HEMLOCK**	**BIGLEAF MAPLE**	**ALDER**	**OTHER**	**BIRCH**	**TOTAL BIOMASS**	**BIOMASS ACRE**
Lowland DF	13,978,843	305,865	306,083	0	782,586	0	0	0	**15,373,377**	**840,994**
Upland DF	13,947,040	0	104,234	0	114,527	0	0	0	**14,165,802**	**472,508**
Mixed Conifer and Deciduous	4,183,166	1,169,136	2,406,714	555,220	1,196,639	73,632	0	558,396	**10,142,903**	**251,249**
Clearcut East	312,272	0	28,703	0	0	28,173	0	0	**369,148**	**169,334**
Clearcut South	31,139	0	1,511	0	0	442	0	0	**33,091**	**23,807**
Clearcut West	595,514	31,042	0	0	15,813	16,561	50,672	0	**709,602**	**197,112**
Total Biomass by Species	**33,047,974**	**1,506,043**	**2,847,246**	**555,220**	**2,109,564**	**118,807**	**50,672**	**558,396**	**40,793,922**	**425,823**
% of Total Biomass by Species	81.0%	3.7%	7.0%	1.4%	5.2%	0.3%	0.1%	1.4%		
Total Carbon Stored by Species	**16,523,987**	**753,022**	**1,423,623**	**277,610**	**1,054,782**	**59,404**	**25,336**	**279,198**	**20,396,961**	**212,912**

Table 4. Total Number of Shrubs, Saplings, Seedlings, Holly, Himalayan Blackberry by Stand						
Stand	**Acres**	**Shrubs**	**Seedlings**	**Saplings**	**Holly**	**Himalayan Blackberry**
Lowland Douglas Fir	18.3	30,824	0	634	115	115
Upland Douglas Fir	44.2	47,608	0	1021	73	0
Mixed Conifer/Deciduous	28.6	28,971	1,132	2,454	897	0
East Clearcut	2.2	1,020	19	57	0	0
South Clearcut	1.4	80	177	0	16	161
West Clearcut	3.7	1,501	0	0	0	0
Totals		**110,004**	**1,328**	**4,166**	**1,101**	**276**

Table 5. Site Index Table (Based on Douglas Fir Average Height/Stand)				
Stand	**Average Height**	**Average age**	**Site Index**	**Site Class**
Lowland DF	150	110	105	III
Upland DF	132	85	100	III
Mixed Conifer	119	85	90	IV

Tables 6a-f. Number of Live Trees/Acre/DBH Range by Stand

6a. Upland Douglas Fir Stand

DBH Range	Douglas Fir	Cedar	Bigleaf Maple
4"→6"	4.4		
6"→8"	10.7		
8"→10"	21.7	2.0	1.7
10"→12"	17.1		1.5
12"→14"	14.9	0.8	
14"→16"	21.1	0.7	
16"→18"	14.1	0.5	0.6
18"→20"	10.8	0.4	
20"→22"	9.7		

22"→24"	7.4		
24"→26"	6.5		
26"→28"	2.9		
28"→30"	1.5		
30"→32"	1.2		
32"→34"	1.0		
34"→36"	0.8		
36"→38"	0.1		
Totals	**145.9**	**4.4**	**3.8**

6b. Lowland Douglas Fir Stand

DBH Range	Douglas Fir	Grand Fir	Bigleaf Maple	Cedar
6"→8"			12.2	
8"→10"	9.5		9.2	
10"→12"	8.5		4.6	
12"→14"	10.0			
14"→16"	5.9			
16"→18"	5.9			
18"→20"	3.6			
20"→22"			2.3	
22"→24"	3.6			
24"→26"	4.7			
26"→28"	5.8			
28"→30"	7.1	0.4		0.8
30"→32"	2.5		0.7	
32"→34"	3.4	0.9		0.6
34"→36"	3.3			0.6
36"→38"	2.7			
38"→40"	2.7			0.7
40"→42"	1.2			
42"→44"	2.7			
44"→46"	1.5		0.3	
46"→48"	0.3			
48"→50"	0.8			
50"→52"	0.3			
Totals	**86.0**	**1.3**	**29.3**	**2.7**

6c. Mixed Conifer and Deciduous Stand

DBH Range	Douglas Fir	Grand Fir	Alder	Bigleaf Maple	Cedar	Birch	Hemlock	Poplar	Spruce	Willow
2"→4"										10.9
4"→6"	5.8	4.9			14.0	12.4				
6"→8"	10.0			3.5		4.5		3.4		
8"→10"		2.7	7.6	4.6	2.0	2.1				
10"→12"		1.7	11.4	2.7		11.7	1.5	3.1		
12"→14"	2.3	1.9	3.8	0.9		5.2	1.2			
14"→16"		1.5	0.7		3.2	4.0				0.9
16"→18"	3.5	1.3	2.9	0.6	2.3	1.8	0.6			
18"→20"	0.5	0.5	1.0	0.5	1.5	1.5	0.5			
20"→22"	0.8			0.4	0.8	0.8	0.9			
22"→24"	0.8	0.7		0.3	3.3	0.3	1.3			
24"→26"	2.3		0.3		2.0		0.9			
26"→28"	0.9			0.5	1.9	0.2				
28"→30"	1.1	0.2		0.2	0.7					
30"→32"	1.5	0.5	0.2		0.4					
32"→34"	0.9	0.2		0.2	1.1					
34"→36"	0.3				0.4					
36"→38"	0.1			0.1	1.0					
38"→40"	0.1	0.2			0.4				0.1	
40"→42"										
42"→44"	0.1									
44"→46"					0.1					
46"→48"					0.1					
48"→50"	0.1				0.1					
50"→52"										
52"→54"					0.1					
54"→56"	0.1									
56"→58"										
58"→60"										
60"→62"										
62"→64"										
64"→66"										
66"→68"										
66"→70"					0.04					

70"→72"										
72"→74"				0.03						
Totals	**31.2**	**16.3**	**27.9**	**14.5**	**35.4**	**44.5**	**6.9**	**6.5**	**0.1**	**11.8**

6d. East Clearcut Stand

DBH Range	Douglas Fir	Cherry	Alder	Grand Fir	Bigleaf Maple
4"→6"		100.3			
6"→8"	49.4	12.4	13.4		
8"→10"	72.1	7.8		8.3	9.3
10"→12"	93.1		6.1	6.3	
12"→14"					
14"→16"	6.8				
Totals	**221.4**	**120.5**	**19.5**	**14.6**	**9.3**

6e. South Clearcut Stand

DBH Range	Douglas Fir	Cedar	Alder
4"→6"	30.3		27.3
6"→8"	56.1	18.2	52.7
8"→10"	45.3		
10"→12"	32.4		
12"→14"	16.9		
14"→16"	8.7		
16"→18"			
18"→20"			
20"→22"			
22"→24"		1.6	
24"→26"			
26"→28"			
28"→30"		1.0	
Totals	**189.7**	**20.8**	**80.0**

6f. West Clearcut Stand

DBH Range	Douglas Fir	Cedar	Alder
6"→8"			30.8
8"→10"	14.5		42.1
10"→12"	47.1		
12"→14"	35.5		
14"→16"	6.0		
16"→18"	3.9	4.6	
18"→20"	3.5		
20"→22"	5.6		
22"→24"	4.7	7.1	
24"→26"			
26"→28"			
28"→30"		1.4	
30"→32"			
32"→34"			
34"→36"			
36"→38"	1.0		
Totals	**121.8**	**13.1**	**72.9**

Table 7. Live Tree Biomass/Acre/DBH Range (lbs)

7a. Upland Douglas Fir Stand

DBH Range	Douglas Fir	Cedar	Bigleaf Maple
4"→6"	958		
6"→8"	3,029		
8"→10"	12,862	865	1,274
10"→12"	16,825		1,313
12"→14"	22,603	936	
14"→16"	45,581	959	
16"→18"	42,369	984	1,770
18"→20"	43,227	1,001	
20"→22"	49,097		
22"→24"	45,506		
24"→26"	49,676		
26"→28"	27,015		
28"→30"	17,264		
30"→32"	15,672		
32"→34"	16,359		
34"→36"	14,371		
36"→38"	2,453		
Totals	**424,867**	**4,745**	**4,357**

7b. Lowland Douglas Fir Stand

DBH Range	Douglas Fir	Grand Fir	Bigleaf Maple	Cedar
6"→8"			4,517	
8"→10"	4,715		4,899	
10"→12"	8,068		6,023	
12"→14"	14,649			
14"→16"	12,682			
16"→18"	16,871			
18"→20"	14,483			
20"→22"			12,908	
22"→24"	24,223			
24"→26"	37,836			
26"→28"	52,324			
28"→30"	81,560	3,504		4,218

30"→32"	32,806		10,063	
32"→34"	53,459	11,122		4,215
34"→36"	60,365			4,215
36"→38"	56,980			
38"→40"	63,917			6,331
40"→42"	32,697			
42"→44"	84,600			
44"→46"	52,122		12,125	
46"→48"	11,844			
48"→50"	36,655			
50"→52"	12,367			
Totals	**765,223**	**14,626**	**50,535**	**18,979**

7c. Mixed Conifer/Deciduous Stand

DBH Range	Douglas Fir	Grand Fir	Alder	Bigleaf Maple	Cedar	Birch	Hemlock	Poplar	Spruce	Willow
2"→4"										851
4"→6"	1,008	877			1,725	2,317				
6"→8"	3,456	1,007		1,154		1,231		1,084		
8"→10"		2,417	4,875	2,600	955	1,436				
10"→12"		2,565	10,365	3,064		12,303	1,210	2,552		
12"→14"	3,000	2,685	5,644	1,732		8,217	1,263			
14"→16"		1,433	1,495		4,159	8,675				1,430
16"→18"	10,744		7,819	1,924	4,281	5,485	1,421			
18"→20"	1,904	3,312	3,236	2,079	3,268	5,714	1,480			
20"→22"	3,973			2,248	2,244	4,030	3,142			
22"→24"	4,170			2,343	11,156	2,033	6,378			
24"→26"	17,463	1,841	1,730		7,770		4,833			
26"→28"	9,161	5,678		5,016	8,850	2,067				
28"→30"	11,834	1,948		2,542	3,316					
30"→32"	19,635		1,777		2,207					
32"→34"	15,336			2,736	7,725					
34"→36"	5,217	2,121			3,311					
36"→38"	2,728			2,915	8,837					
38"→40"	2,837				3,317				1,643	
40"→42"										

42"→44"	2,979									
44"→46"					1,111					
46"→48"					1,112					
48"→50"	3,186				1,115					
50"→52"										
52"→54"					1,119					
54"→56"	3,417									
56"→58"										
58"→60"										
60"→62"										
62"→64"										
64"→66"										
66"→68"										
66"→70"					1,141					
70"→72"										
72"→74"				4,308						
Totals	**122,048**	**25,884**	**36,941**	**34,661**	**78,719**	**53,508**	**19,727**	**3,636**	**1,643**	**2,281**

7d. Clearcut East Stand

DBH Range	Douglas Fir	Cherry	Alder	Grand Fir	Bigleaf Maple
4"→6"		13,873			
6"→8"	19,900	5,656	4,603		
8"→10"	43,132	6,215		4,027	5,535
10"→12"	88,611		5,421	4,379	
12"→14"					
14"→16"	13,821				
Totals	**165,464**	**25,744**	**10,024**	**8,406**	**5,535**

7e. Clearcut South Stand

DBH Range	Douglas Fir	Cedar	Alder
4"→6"	5,292		5,204
6"→8"	17,933	4,787	17,097
8"→10"	26,823		
10"→12"	29,223		
12"→14"	24,029		
14"→16"	17,151		
16"→18"			

18"→20"			
20"→22"			
22"→24"		5,842	
24"→26"			
26"→28"			
28"→30"		5,797	
Totals	**120,451**	**16,426**	**22,301**

7f. Clearcut West Stand

DBH Range	Douglas Fir	Cedar	Alder
6"→8"			7,179
8"→10"	9,039		25,356
10"→12"	50,456		
12"→14"	54,282		
14"→16"	11,331		
16"→18"	12,724	7,413	
18"→20"	13,027		
20"→22"	27,780		
22"→24"	29,154	23,435	
24"→26"			
26"→28"			
28"→30"		7,729	
30"→32"			
32"→34"			
34"→36"			
36"→38"	19,153		
Totals	**226,946**	**38,577**	**32,535**

Table 8. Biomass Growth in Pounds Per Acre/DBH Range/Year

8a. Upland Douglas Fir Stand

DBH Range	Douglas Fir	Cedar	Bigleaf Maple
4"→6"	286		
6"→8"	675		
8"→10"	1,772	115	185
10"→12"	1,597		153
12"→14"	1,563	59	
14"→16"	2,452	47	
16"→18"	1,855	39	91
18"→20"	1,622	86	
20"→22"	1,638		
22"→24"	1,389		
24"→26"	1,383		
26"→28"	692		
28"→30"	412		
30"→32"	350		
32"→34"	339		
34"→36"	285		
36"→38"	47		
Totals	**18,357**	**346**	**429**

8b. Lowland Douglas Fir Stand

DBH Range	Douglas Fir	Grand Fir	Bigleaf Maple	Cedar
6"→8"			1,040	
8"→10"	699		819	
10"→12"	776		601	
12"→14"	1,029			
14"→16"	685			
16"→18"	753			
18"→20"	542			
20"→22"			438	
22"→24"	716			
24"→26"	1,032			
26"→28"	1,332			
28"→30"	1,935	88		84

30"→32"	732		240	
32"→34"	1,118	252		74
34"→36"	1,187			74
36"→38"	1,064			
38"→40"	1,136			99
40"→42"	558			
42"→44"	1,359			
44"→46"	799		209	
46"→48"	175			
48"→50"	512			
50"→52"	169			
Totals	**18,308**	**340**	**3,347**	**331**

8c. Mixed Conifer and Deciduous Stand

DBH Range	Douglas Fir	Grand Fir	Alder	Bigleaf Maple	Cedar	Birch	Hemlock	Poplar	Spruce	Willow
2"→4"										494
4"→6"	328	252			588	832				
6"→8"	709			277		314		239		
8"→10"		154	670	425	121	204				
10"→12"		118	1,035	321		1,234	120	264		
12"→14"	220	182	394	128		599	96			
14"→16"		157	81		216	492				86
16"→18"	468	142	353	100	177	252	66			
18"→20"	71	65	255	91	118	353	59			
20"→22"	133			77	62	120	99			
22"→24"	126	104		72	284	54	178			
24"→26"	484		44		181		126			
26"→28"	232			132	189	48				
28"→30"	282	46		65	69					
30"→32"	438	135	37		42					
32"→34"	318	44		61	137					
34"→36"	104				56					
36"→38"	50			58	143					
38"→40"	49	41			51				28	
40"→42"										
42"→44"	47									

44"→46"					15					
46"→48"					15					
48"→50"	45				14					
50"→52"										
52"→54"					13					
54"→56"	43									
56"→58"										
58"→60"										
60"→62"										
62"→64"										
64"→66"										
66"→68"										
66"→70"					10					
70"→72"										
72"→74"				46						
Totals	**4,147**	**1,399**	**2,869**	**1,853**	**2,501**	**4,502**	**744**	**503**	**28**	**580**

8d. East Clearcut Stand

DBH Range	Douglas Fir	Cherry	Alder	Grand Fir	Bigleaf Maple
4"→6"		5,705			
6"→8"	3,846	1,161	986		
8"→10"	5,917	841		610	884
10"→12"	8,536		546	486	
12"→14"					
14"→16"	759				
Totals	**19,058**	**7,707**	**1,532**	**1,096**	**884**

8e. South Clearcut Stand

DBH Range	Douglas Fir	Cedar	Alder
4"→6"	1,723		1,716
6"→8"	3,775	956	3,751
8"→10"	3,710		
10"→12"	2,875		
12"→14"	1,706		
14"→16"	955		
16"→18"			
18"→20"			
20"→22"			
22"→24"		144	
24"→26"			
26"→28"			
28"→30"		114	
Totals	**14,744**	**1,214**	**5,467**

8f. West Clearcut Stand

DBH Range	Douglas Fir	Cedar	Alder
6"→8"			1,816
8"→10"	1,223		3,569
10"→12"	4,635		
12"→14"	3,736		
14"→16"	642		
16"→18"	538	324	
18"→20"	505		
20"→22"	933		
22"→24"	885	602	
24"→26"			
26"→28"			
28"→30"		152	
30"→32"			
32"→34"			
34"→36"			
36"→38"	352		
Totals	**13,449**	**1,079**	**5,385**

APPENDIX B: Figures

Figure 1: Estimated distribution of Douglas Fir tree heights based on D.B.H. Distribution for Lowland and Upland Douglas Fir

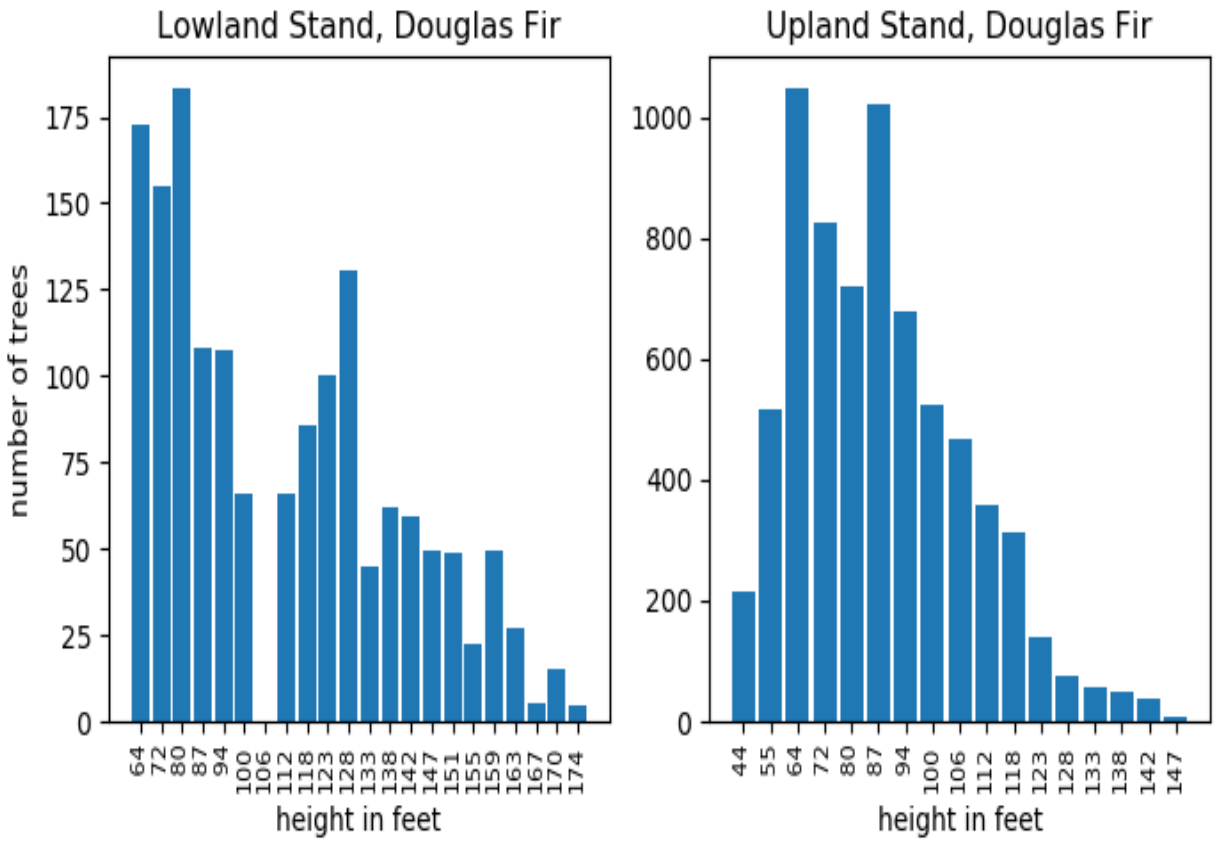

Figure 2: Estimated Number of Live Trees per Acre by Stand

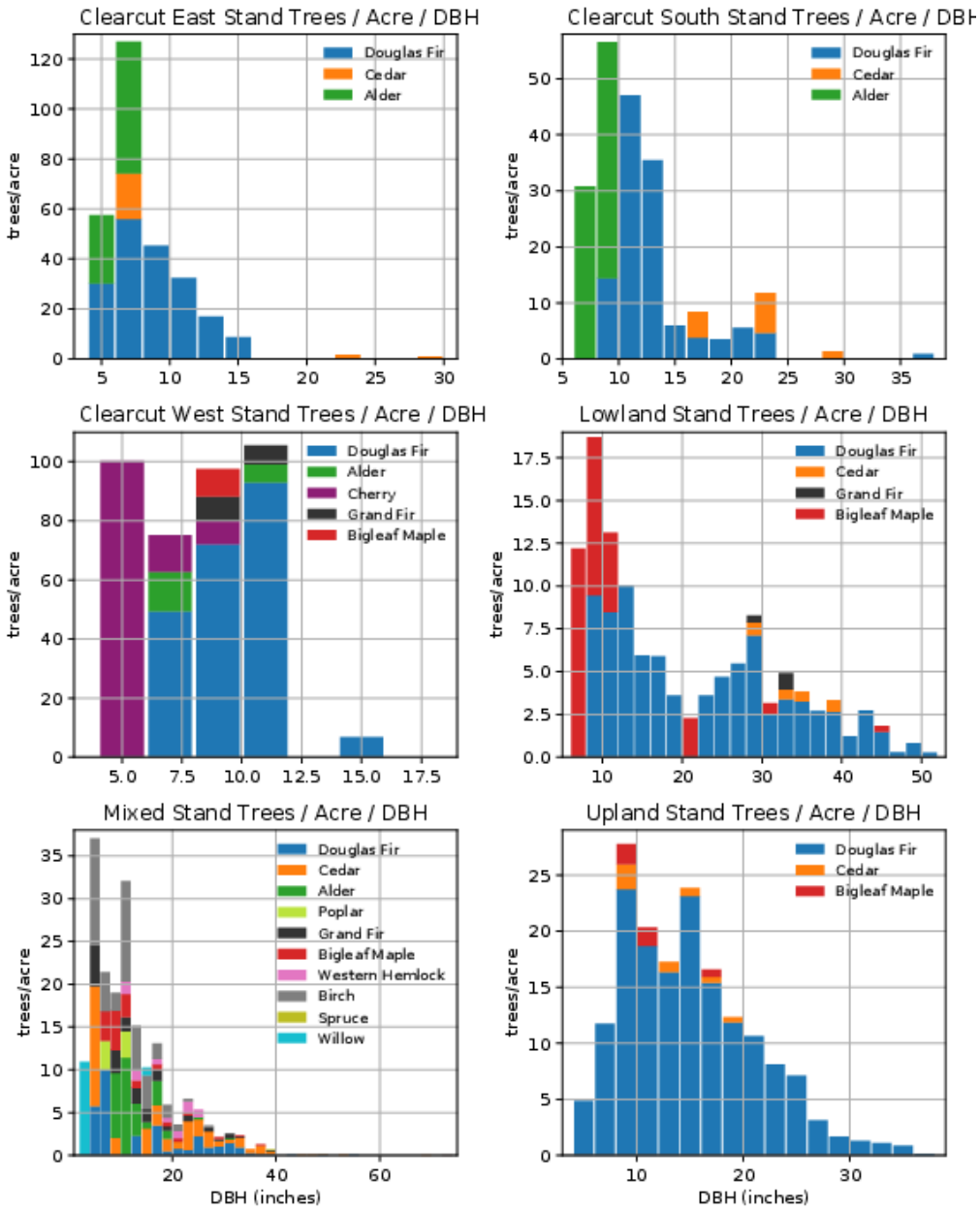

Figure 3: Estimated Number of Dead Trees per Acre by D.B.H. Range

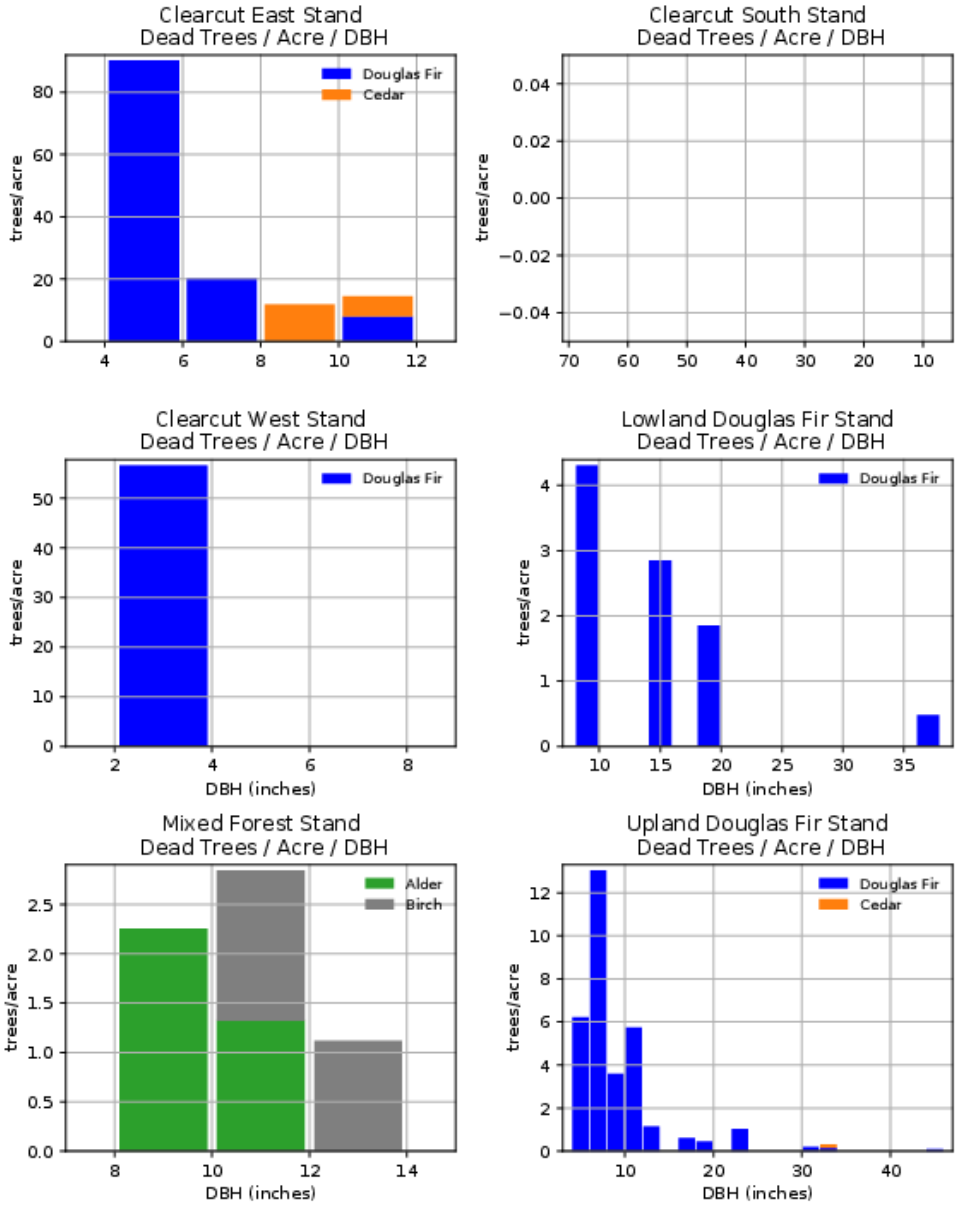

Figure 4: Estimated Stand Biomass per Acre by D.B.H. Range

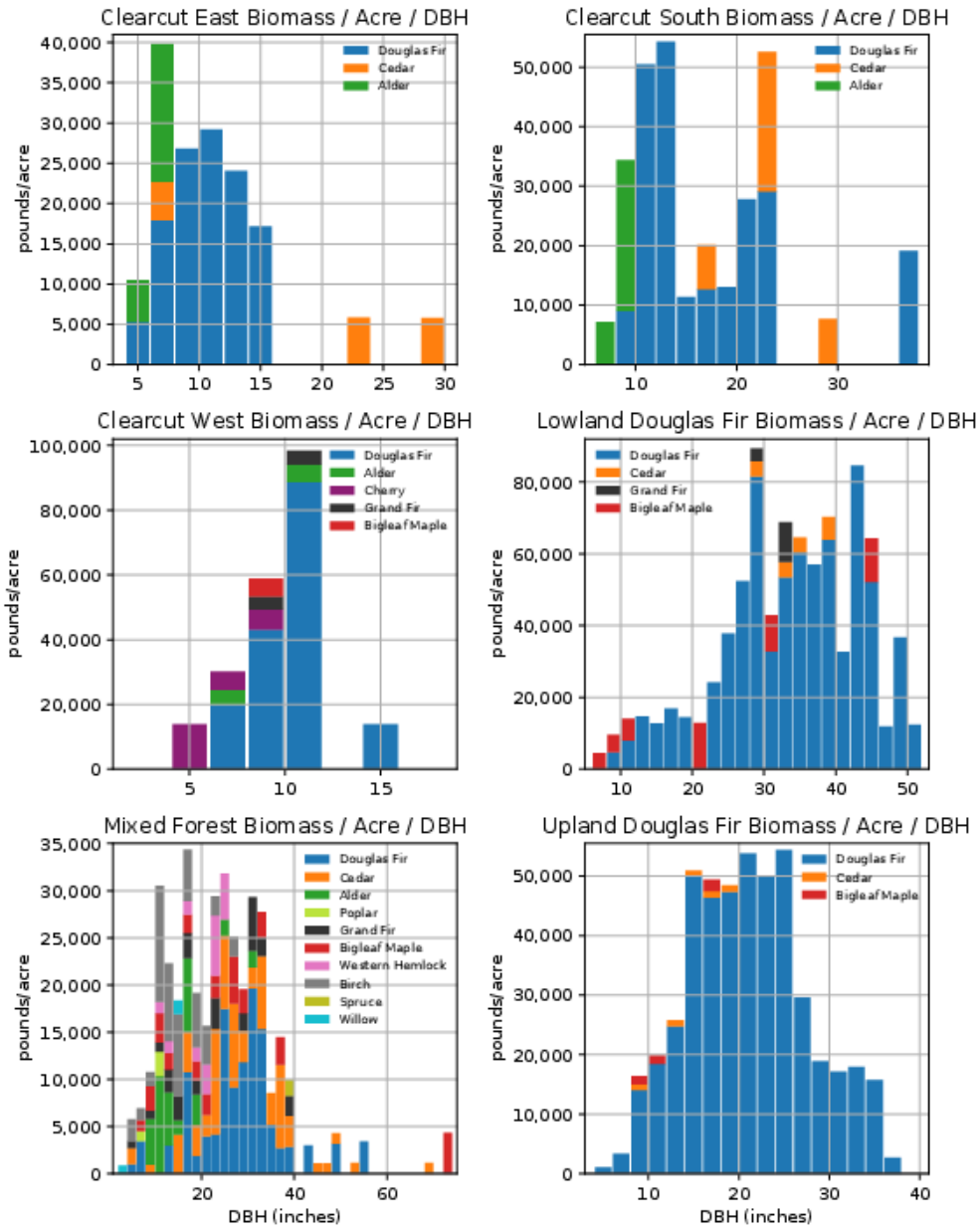

Figure 5: Otto Preserve Forest Stands Map

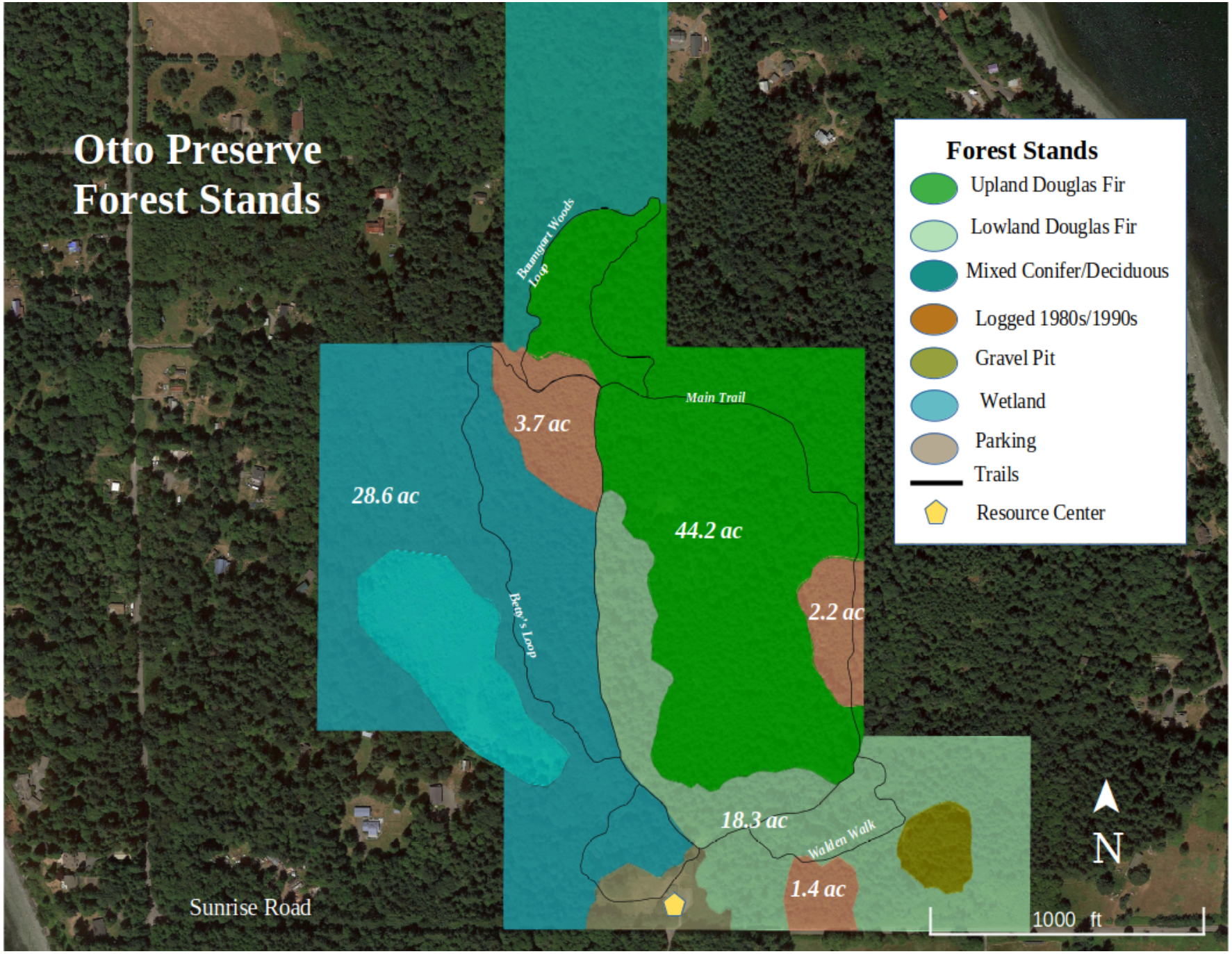

Figure 6: Otto Preserve Forest Stands Map with Inventory Plot Locations