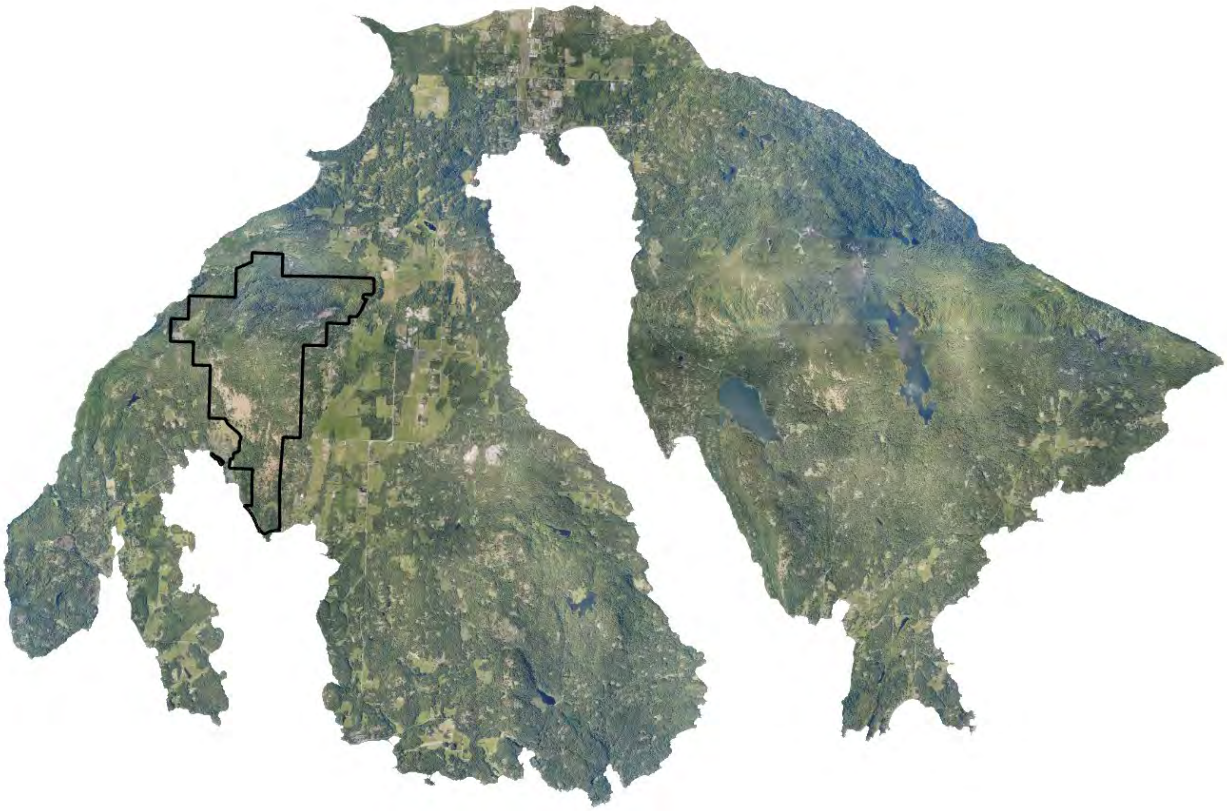
Turtleback Mountain Preserve & Turtlehead Preserve

Action Plan for Forest Health and Climate Change Resiliency



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BACKGROUND AND SCOPE OF WORK

Rain Shadow Consulting, LLC. (Rain Shadow) was retained jointly by the San Juan County Land Bank (Land Bank) and the San Juan Preservation Trust (Preservation Trust) in 2020 to provide recommendations for short and long-term forest management within the Turtleback Mountain Preserve and Turtlehead Preserve's forested areas. Funding for the effort was provided by the Preservation Trust-managed stewardship endowment for Turtleback Mountain Preserve. The 1,578-acre Turtleback Mountain Preserve was acquired in 2006 through a joint effort between the Land Bank and the San Juan Preservation Trust (SJPT) with supporting contributions from the general public. The 141 additional acres comprising the Turtlehead Preserve were permanently protected in 2012, after the San Juan Preservation trust purchased the 111-acre parcel that separated the Turtleback Mountain Preserve and the 30-acre Turtlehead Preserve, which had been previously donated to the SJPT by the landowner in 1990. In July 2020, a private donation to the Land Bank resulted in the addition of 35.5 acres to the southern end of the Turtleback Mountain Preserve, extending it to the shoreline of West Sound and bringing the total size of the two preserves to just under 1,800 acres.

In August 2008, the Land Bank's "Turtleback Mountain Preserve Stewardship and Management Plan" outlined broad recommendations under the overarching goal "to maintain the property's outstanding ecological and scenic qualities while providing opportunities for low-impact public, educational, and scientific access." With extensive logging being a significant part of Turtleback's past management, the Land Bank suggested it would consider continuing limited forestry activities to meet ecological goals, including increasing biodiversity and old-growth characteristics, reducing fire danger, and restoring areas of Garry oak savanna. Rain Shadow was also asked for recommendations that place an emphasis on forest resiliency, climate adaptation, and carbon sequestration.

Specifically, Rain Shadow was tasked with the following:

1. Relocating and remeasuring approximately 20 permanent plots to determine mortality and growth rates.
2. Delineating forest management units (FMUs) as subunits of forest stand types
3. Using the forest management units (FMUs), creating prioritized management actions and a phased timeline for implementation, considering Land Bank staff capacity, contractor availability, and continued public use. Recommending management actions that are consistent with established goals, address specific objectives, and consider the following:
    - Reducing fire risk
    - Identifying and protecting critical areas

- Minimizing soil impacts through timing of management actions and use of existing roads and corridors
- Preventing new introductions of invasive plants
- Identifying target densities of snags and woody debris to enhance wildlife habitat
- Promoting public safety and education through use of signage and area closures
- Optimizing labor, equipment, and timing in planning to reduce costs

4. Developing cost estimates associated with recommended management actions and providing details about permits and/or regulatory issues affecting management actions.
5. Installing six new 0.1-acre permanent monitoring plots on the Turtlehead Preserve, consistent with the plot protocols used in 2010.

SUMMARY

During the summer of 2020, Rain Shadow staff completed remeasurement of 24 of the existing permanent plots established in 2010 and installed six new plots throughout the Turtlehead Preserve. Based on our field work, along with maps, aerial photographs, Lidar data, county soils maps, and other geographic data, we added the Turtlehead Preserve to the existing Turtleback Mountain Preserve forest stands map. From there, we subdivided five existing stand types—dry Douglas-fir (stand 1), alder mixed conifer (stand 2), Douglas-fir transitional (stand 3), mesic Douglas-fir (stand 4) and mesic mixed conifer (stand 5) into 73 forest management units (FMUs). FMUs were determined largely based on topography, as terrain greatly impacts the type of equipment that can be used, and access to existing roads, trails, and former skid roads.

Management recommendations include ongoing monitoring, the installation of shaded fuel breaks along roads and trails for fire safety, upgrades and maintenance along access roads for management purposes, and five silvicultural treatment types for the different FMUs. Management activities have been recommended to enhance forest health and resiliency, mitigate fire risk, and restore and maintain a variety of forest and habitat types throughout the Turtleback Mountain and Turtlehead Preserves. Although this document provides management recommendations and associated cost estimates, the extent and timing of implementation are subject to a variety of factors including but not limited to public input, available funding, Land Bank staffing and available contractor and ground crews.

PERMANENT PLOT REMEASUREMENT & NEW PLOT ESTABLISHMENT

During the 2020 summer field season, Rain Shadow's field crew located and re-measured 24 of the 25 permanent monitoring plots established during the 2010 Forest and Carbon Inventory, and we established and measured six new permanent monitoring plots within the Turtlehead Preserve (Figure 1). The 2010 inventory's goal was to quantify the amount of above-ground

biomass in the form of total biomass, merchantable log volumes, and forest carbon. Carbon estimates were calculated for the purpose of generating carbon offsets for climate change registries, and biomass and volume estimates were calculated for each stand type using Forest Vegetation Simulation (FVS) software. Forest growth was modeled for a 50-year period with outputs every 5 years, and results were presented for three management scenarios including no management, commercial thin, and a repeat thin targeting only small diameter classes.

The first phase of the 2010 inventory was to map and describe the five forest stand types found throughout the Turtleback Mountain Preserve; these stand types are described in detail later in this report and now serve as the basis for newly-created Forest Management Units (FMUs). After delineating stand types Rain Shadow collected data from 211 variable radius plots, established by running north-south or east-west transects through each stand with plots at equal intervals along a grid, with the ultimate goal of measuring between five and 25 plots per stand. Twenty-five of these variable radius plots were then converted to fixed-radius 0.1-acre permanent plots, selected based on geographic position to be representative of Turtleback's stand types.

With few variations, we followed the original 2010 protocols in re-measuring the existing permanent plots and establishing new ones (see Appendix B: Permanent Plot Monitoring Protocols). Plot measurements included data collection on live overstory trees, snags, down woody debris, woody species regeneration, and shrubs and herbaceous plants for a total of 30 plots – five from the dry Douglas fir stand type (stand 1), three from the alder mixed conifer stand type (stand 2), two from the Douglas-fir transitional stand type (stand 3), 15 from the mesic Douglas-fir stand type (stand 4), and five from the mesic mixed conifer stand type (stand 5). One previously established plot from the dry Douglas-fir stand type was not re-measured in 2020. Of the newly established plots in the Turtlehead Preserve, five are in the mesic Douglas-fir stand type (stand 4) and one is in a mesic mixed conifer stand (stand 5). These new plots were located randomly, but the Turtlehead preserve is largely made up of mesic Douglas-fir, with smaller areas of mesic mixed conifer and dry Douglas fir, hence the overrepresentation of plots from the mesic Douglas-fir stand type.

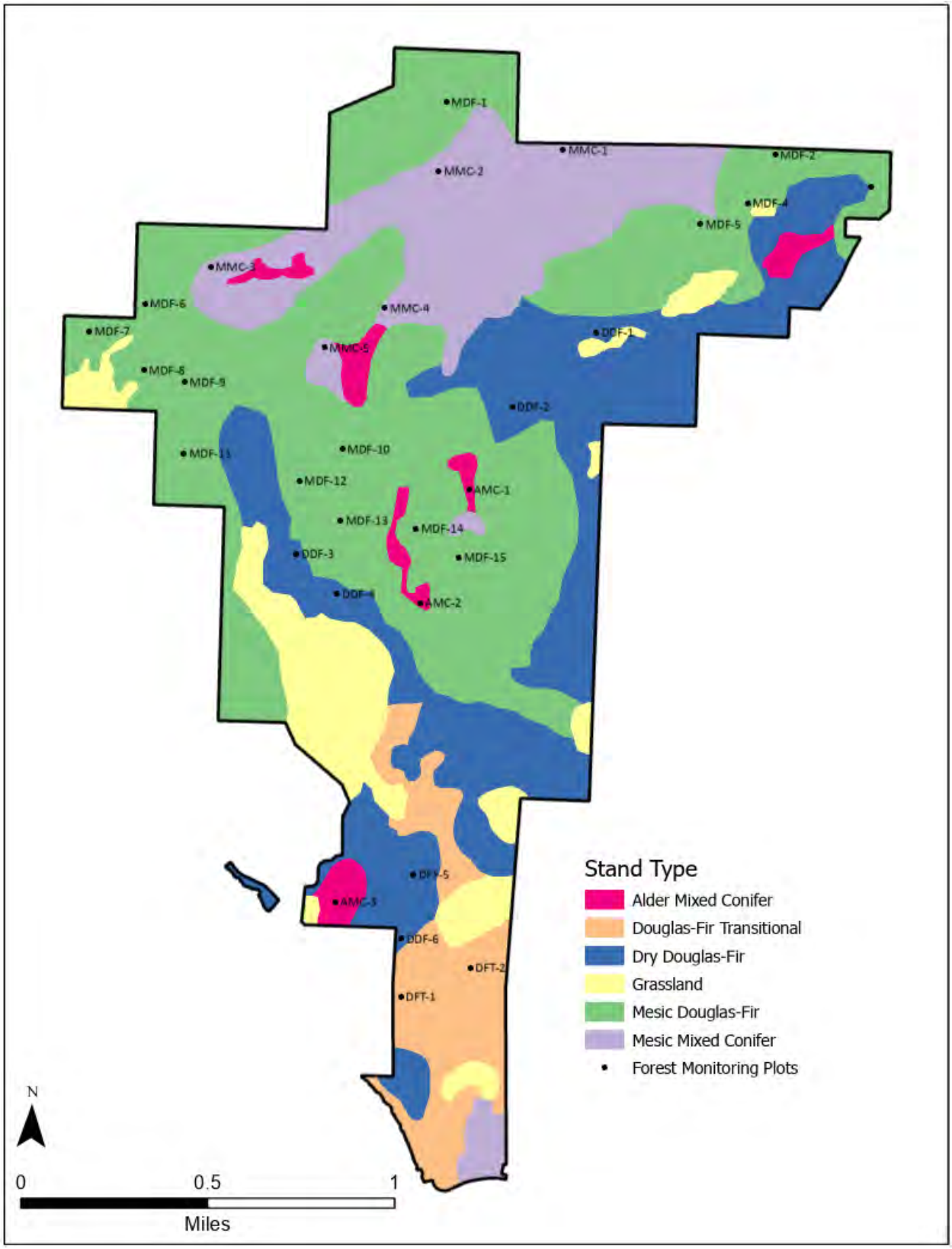


Figure 1 - Turtleback and Turtlehead permanent monitoring plots overlaid on the stand type map.

Findings

The relatively small number of plots measured in 2020 compared to the 211 measured in 2010 makes direct comparison of the data somewhat difficult, particularly at the stand level for the alder mixed conifer and Douglas-fir transitional stand types, with only three and two permanent plots, respectively. We did directly compare the 24 plots that were measured in 2010 and in 2020 to look for general trends in growth and mortality.

On those 24 plots, 505 live trees and 83 snags were measured in 2010 for a total of 588 overstory trees. In 2020, we measured 437 live trees and 105 snags, for a total of 542 overstory trees. Two new trees were measured in 2020 (one bigleaf maple and one Douglas-fir), and 48 trees that had previously been living or standing snags were discovered to be naturally dead and down, removed (3 trees in one plot in a Garry oak restoration area in the Douglas-fir transitional stand), or not found and assumed to be dead and down.

Comparing the trees that were alive in 2010 and were dead in 2020, we found mortality across all species of 7.5% for stand 1, 27.3% for stand 2, 0% for stand 3, 9.8% for stand 4, 19.6% for stand 5, and 13.5% overall. Mortality by species (Table 1) indicates that mortality is weighted much more heavily on the shade tolerant species (hemlock, grand fir, and western redcedar), lending support that drought stress is a major contributing factor. Drought stress is almost certainly becoming worse due to the gradual warming of the climate but is also exacerbated by high tree density. Grand fir mortality may also be driven, in part, by the interaction of insects and drought stress. The fir engraver beetle (*Scolytus ventralis*) has been an active agent of mortality in drought stressed and senescing grand fir in the San Juan Islands over the last 20 years. The relatively high mortality of alder is likely due to the age of these stands and high proportion of senescing alder trees.

Table 1 – Mortality by species across all stand types from 2010 to 2020

Species	% Mortality	New snags in 2020
Western hemlock	38.5	10
Red alder	34.1	14
Grand fir	33.3	7
Western redcedar	21.3	13
Douglas-fir	7.8	26
Shore pine	7.1	1

To compare growth between 2010 and 2020, we calculated the percent increase in DBH for trees that were alive in 2010 and still alive in 2020. Overall, we found a 10.3% increase for stand 1 (n=62), an 8.8% increase for stand 2 (n=48), a 30.0% increase for stand 3 (n=16), a 10.1% increase for stand 4 (n=223), a 10.5% increase for stand 5 (n=86), and a 10.6% increase overall

(n=435). Percent increase by species across all stands is noted in Table 2 below, with grand fir and western hemlock showing the greatest increases in DBH (except for juniper, an outlier due to the small sample size of two trees).

Table 2 – Percent increase in diameter by species across all stands from 2010 to 2020, with average DBH for each year

Species	% Increase in DBH	Mean DBH 2010	Mean DBH 2020	N
Douglas fir	11.0	11.5”	12.8”	304
Grand fir	20.5	6.8”	8.2”	14
Juniper	48.5	3.3”	4.9”	2
Lodgepole pine	7.6	10.1”	10.8”	13
Pacific madrone	5.6	6.0”	6.3”	6
Red alder	5.3	11.9”	12.5”	27
Western redcedar	9.4	13.2”	14.4”	48
Willows	3.7	6.3”	6.5”	3
Western hemlock	14.3	8.7”	10.0”	16
Garry oak	9.2	11.4”	12.5”	2

Perhaps a better indicator of growth is volume, which we compared for all species across stand types between 2010 and 2020. Douglas-fir transitional (stand 3) showed the greatest increase in volume, 64.9%, while alder mixed conifer (stand 2) showed the smallest increase in volume at 9.7%. However, these stand types have the fewest plots for comparison (two plots for stand 3 and three plots for stand 3), and the plots measured may or may not represent the stand type as a whole. Volume increases were more consistent for stands 1, 4, and 5, with a 22.1% increase in stand 1, a 21.45 increase in stand 4, and a 13.5% increase in stand 5. The overall increase in volume across all stand types is consistent with Turtleback and Turtlehead’s forests being in a state of regrowth after many years of logging across the preserves.

Complete monitoring data, including the baseline data for the newly established plots, all coarse woody debris data, and understory data can be found in the spreadsheet *Turtleback_2020_Data-New_Plot_IDs_GPS_Coords.* 2020 plot photos (taken at each plot facing north, east, south, and west) will be provided to the Land Bank and Preservation Trust electronically.

Monitoring recommendations

Maintaining the 31 permanent plots for long-term monitoring roughly every 10 years will allow the Land Bank and Preservation Trust to continue to collect valuable data about the state of Turtleback and Turtlehead’s forests and provide quantitative metrics to assess the impacts of future management actions. Adding additional plots in the alder mixed conifer and Douglas-fir

transitional stands would provide more data for comparison purposes with each stand type, and establishing additional plots by FMU would enable comparison of various management treatments. Including height measurements for all live trees rather than a subsample of live trees is time-consuming in the field but would allow for better estimates of growth and volume. One draft of the original plot protocols in 2010 included marking each end of the coarse woody debris transects with rebar and PVC pipe; however, as no such markings were found at any of the plots, CWD transects appear to have been completed by taking bearings at each plot and using a measuring tape. Adding markers for the CWD transects would increase efficiency in field data collection and ensure that the transects are in the same location each time data is collected, as small errors in taking and following compass bearings can result in inconsistency.

Forest Management Units

A primary goal of Rain Shadow's work was the establishment of Forest Management Units (FMUs) as subunits of the existing stand types. These FMUs serve as discrete units for future management actions, based on the recommendations that follow. Importantly, these units will aid in the implementation of ecologically driven management actions to increase forest resiliency and ecological integrity.

The forests of Turtleback are diverse and dynamic. The diversity in both structure and composition is driven by various ecological processes and by geophysical and edaphic factors. The primary ecological processes influencing diversity, beyond growth and succession, are disturbances, both abiotic and biotic, and both natural and planned (human caused). Examples of abiotic disturbances include fire, wind, snow, and extreme temperature events. Examples of biotic disturbances include insects, root rot pathogens, and intensive deer browse. Fire, an abiotic process, historically interacted on the Turtleback landscape as part of an intentional land management practice of the indigenous Coast Salish people. Essentially, a planned disturbance.

Prior to Euro-American settlement, natural disturbance events, including the long history of intentional burning, operated within a *historic range of variability* in terms of their effects on local environment. The effects can be characterized in different ways including duration, extent, spatial pattern, intensity, mortality, and many other factors depending on the particular disturbance. Using fire as an example, historic fires typically burned with moderate to low intensity, occurred every 2-15 years, were moderate in size, and patchy in distribution. More in-depth and quantitative characterization of the local fire history can be found in a number publications (Agee, 1987; Higuera et. al, 2005; Peterson and Hammer, 2001; Sprenger and Dunwiddie, 2011; Spurbeck and Keenum, 2003).

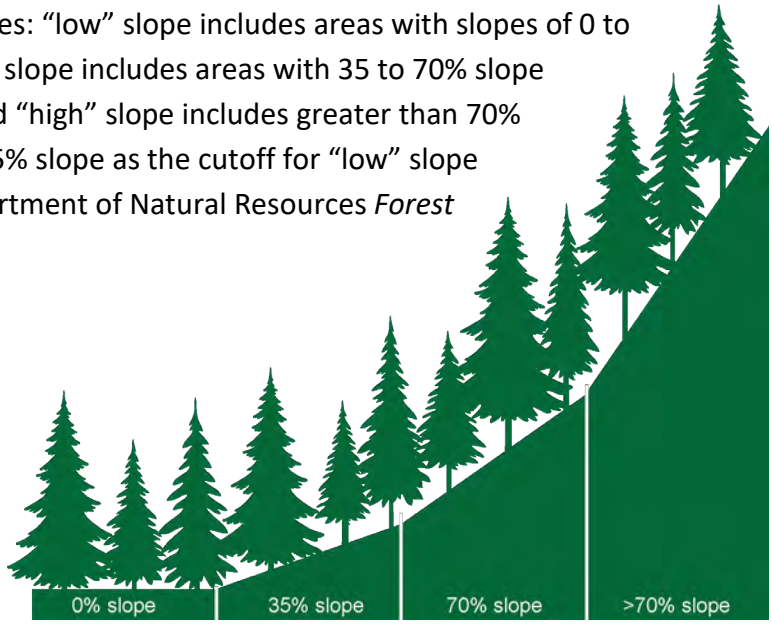
With roughly 150 years since the last fires, it is widely accepted that a fire burning under current fuel conditions would burn with much greater intensity, be much larger in size, and cause high rates of tree mortality—essentially, well outside the historic range of variability. The ecological consequences of such a fire would lead to significant loss of biological resources and likely a strong departure from the diverse and multi-aged stand structures that currently comprise Turtleback.

The recommended treatments described in this report are designed, in many ways, to restore the overall structure and composition of the forested landscape to a condition similar to historic/pre-settlement conditions. These reference points are drawn from extensive field sampling and observations, experience, and a thorough literature review. The closer the forests can parallel the historic conditions, the better they will respond to future planned and unplanned disturbance events and, importantly, exhibit greater resilience in the face of global climate change.

Delineation

Due to high degree of heterogeneity in microtopography, forest structure, natural disturbance, and past timber harvesting, the forests growing on Turtleback exhibit high variability in density and age. This challenged conventional stand delineation and resulted in a process of defining workable forest management units (FMUs) based primarily on accessibility and operability. Combined with the previous general stand typing, we chose to define our FMUs primarily by overlaying three distinct categories of slope and then considering proximity to forest access roads.

We divided slope into three categories: “low” slope includes areas with slopes of 0 to 35% (0 to 19.29 degrees), “medium” slope includes areas with 35 to 70% slope (19.30 degrees to 34.99 degrees) and “high” slope includes greater than 70% slope (35 to 90 degrees). We used 35% slope as the cutoff for “low” slope areas because the Washington Department of Natural Resources *Forest*



Practices Illustrated[1] suggests the use of ground-based felling systems such as tracked skidders, shovels, and fully-mechanized silvicultural systems only on slopes up to 35% in western Washington. Steeper slopes are more prone to soil erosion and compaction that can have long-lasting detrimental impacts. Between 35 and 70% slope, silvicultural systems and road/landing construction need to be planned carefully to minimize impact and avoid damaging resources. Areas with slopes above 70% are likely to include difficult to navigate terrain and an increasing occurrence of rock outcrops, making many forest management practices impractical and unsafe.

We used a combination of spatial datasets to visualize and delineate Turtleback's low, medium, and high slope areas, including ESRI's *Terrain: Slope Map* layer (for visualization) and *Terrain: Slope in Degrees* layer (for analysis), along with San Juan County's *10-foot Cartographic Contours* layer and the San Juan County 2019 Digital Terrain Model Lidar imagery, available from the Washington Lidar Portal. By reclassifying the Slope in Degrees layer into our three slope categories we produced a map of the areas of low, medium, and high slope within the Turtleback and Turtlehead preserves. With the exception a few larger areas of high (steep) slope in the northwestern part of the preserve, many of the areas of medium and high slope are scattered in narrow bands covering only small areas within each forest stand. To establish forest management units, we overlaid our stand type map on the three-category slope map and hand-digitized forest management units based on stand type and areas of similar slope category (see Figure 2 for a visual overview of the process). Our goal was a minimum forest management unit size of five acres and a maximum of 100 acres; however, we made some exceptions where areas of a certain stand type were already smaller than 5 acres, or where there were areas with significantly different terrain than adjacent areas (e.g., an area of consistent high slope adjacent to an area of consistent low slope). The result was 73 distinct forest management units, plus 11 grassland management units (Figure 3 and Appendix A: Forest Management Unit Maps). Because of the high degree of topographic variability across the preserve, each FMU may still contain areas with a variety of topography but should be generally characterized by its assigned slope category. Forest management units were assigned a unique identifier based on a three-letter stand type abbreviation, slope category abbreviation, and a number (i.e., MDF-L-01 indicates mesic Douglas-fir stand type, low slope, unit number 1), and are generally numbered from north to south within each stand type and slope category.

[1] https://www.dnr.wa.gov/publications/fp_fpi_complete.pdf

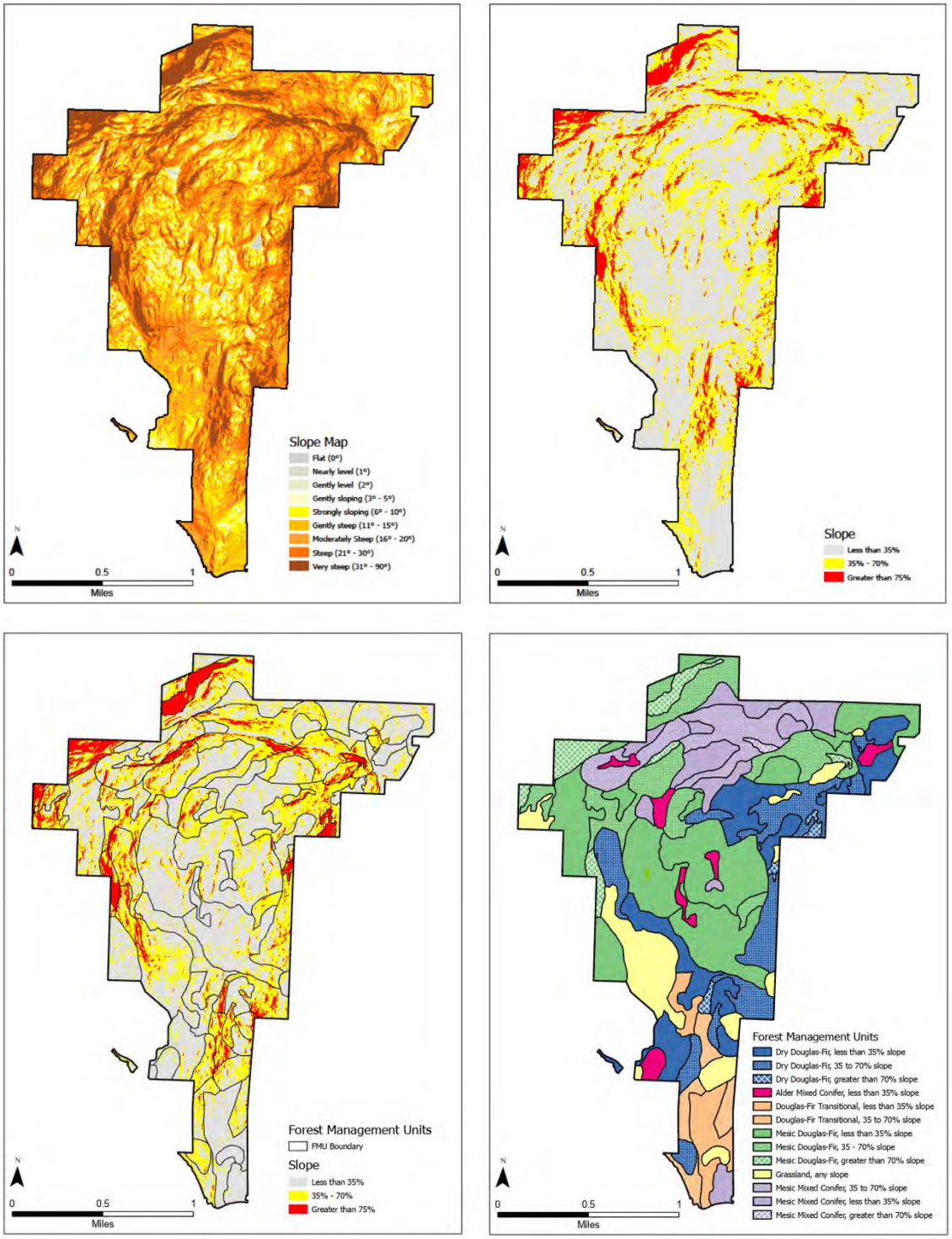


Figure 2 - This series of maps shows the process of delineating Forest Management Units based on slope. The first map shows ESRI's "Terrain: Slope Map" layer for a visual overview of the variation in slope across the Turtleback and Turtlehead Preserves. The second map shows ESRI's Slope in Degrees map, reclassified into our three slope categories. The third map shows the forest management units outlined in black, overlaid on the map showing areas of medium (35-70%) slope and high (70%+ slope). Variation still exists within FMUs, but in general, they are defined by the predominant slope category. The fourth map shows the final FMU outlines.

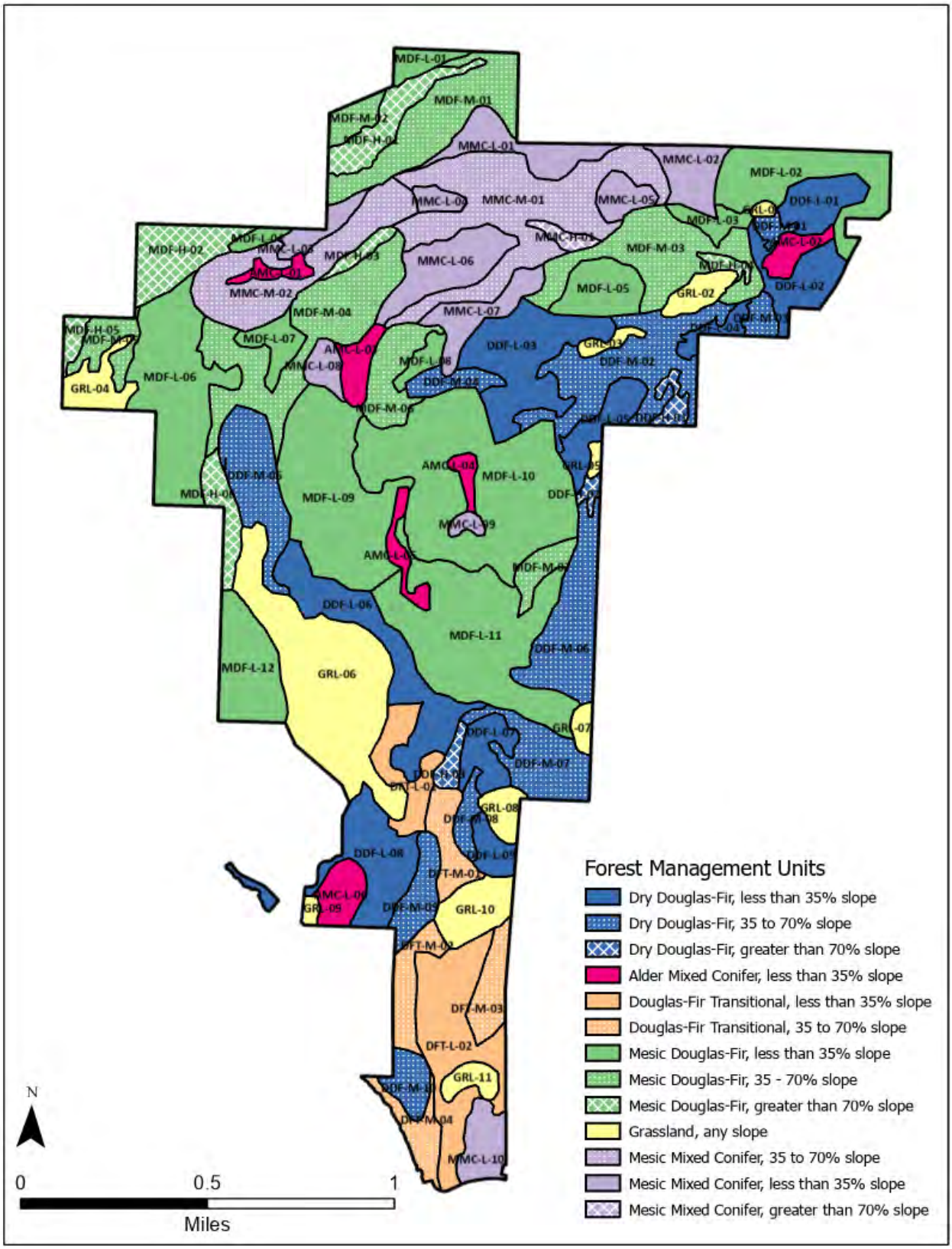
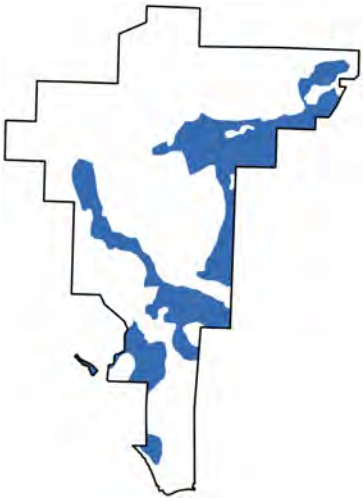


Figure 3 - Forest Management Units. For larger-scale maps with roads, streams, and wetlands see Appendix A.

Forest Stand Types

Turtleback and Turtlehead's forest stand types are based on the five stands defined in the 2010 Turtleback Mountain Forest and Carbon Inventory, completed by Rain Shadow Consulting and Goshawk Ridge Consulting, Inc. for the San Juan County Land bank. Stand types defined below have been updated based on the findings of the 2020 re-measurement of the Turtleback permanent monitoring plots. Stands in the Turtlehead preserve were mapped based on San Juan County's 2019 digital orthophotos, ground reconnaissance, and findings when establishing six new permanent monitoring plots within the Turtlehead Preserve according to the protocols established in 2010.

Type 1: Dry Douglas-Fir (417 acres, FMU abbreviation DDF)



The dry Douglas-fir stand type is found on moderate to steep slopes with aspects ranging from southeast to south to southwest. The average age for this stand type is 100 years (age samples taken from dominant Douglas-fir trees) though individual stands vary in age considerably from 49 to 148 years old). These stands are typically multi-aged with two or three cohorts, though numerous small patches exist where only a single cohort is present. Recent logging activity (around 2005), especially in the eastern portion of this stand type, appears to be somewhat less compared with other stand types. This is likely due to the steepness and inaccessibility of these areas. A small number of scattered lodgepole pine (*Pinus contorta*), Pacific madrone (*Arbutus menziesii*), and Garry oak (*Quercus garryana*) are found throughout this type on the edge of openings and large rock outcrops. Over the 10-year remeasurement period for permanent plots, this stand type showed modest mortality (7.5%)—all Douglas-fir—with an average diameter increase of 10.4% and an overall increase in merchantable volume of 22.1%.

The dry Douglas-fir stand type is often bordered by grasslands or the Douglas-fir transitional type and exhibits many signs of a more open, woodland-like historical structure. Encroachment driven processes that significantly accelerated at the time of fire exclusion (when traditional coast Salish burning practices ceased), have largely driven vegetation changes over the last 110-140 years. Over the last 40-60 years the woodland structure has dramatically shifted to closed forest. (Chappell, June 2006) Due to aspect, edaphic constraints such as perched water and shallow soils, as well as other factors, these stands are susceptible to drought stress. Mortality in suppressed trees and trees bordering balds and outcrops appears to be increasing, both from excessive drought stress and co-stresses with pathogenic fungi. This stand type, perhaps more than other types, would benefit from addressing these threats through well-timed ecologically

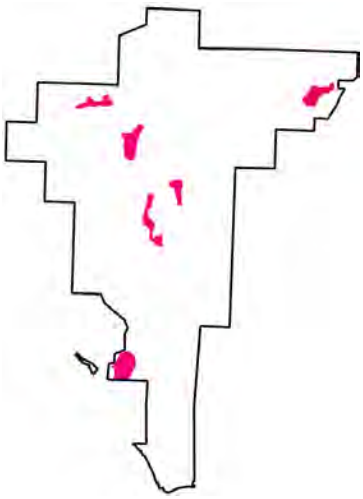
based density reduction. Returning captured charcoal to the soil, coupled with thinning, would maximize the carbon sequestration capacity of the stand and increase long-term resilience as well as fire safety.

The Dry Douglas-fir stand type includes 23 unique forest management units (Table 3).

Table 3 - Dry Douglas-fir FMUs

Dry Douglas Fir (Stand Type 1 - 417 acres)					
FMU ID	**Slope**	**Acres**	**FMU ID**	**Slope**	**Acres**
DDF-L-01	Low	16.50	DDF-M-03	Medium	5.48
DDF-L-02	Low	19.80	DDF-M-04	Medium	8.68
DDF-L-03	Low	46.75	DDF-M-05	Medium	31.47
DDF-L-04	Low	6.13	DDF-M-06	Medium	37.85
DDF-L-05	Low	15.23	DDF-M-07	Medium	27.15
DDF-L-06	Low	45.35	DDF-M-08	Medium	6.56
DDF-L-07	Low	14.54	DDF-M-09	Medium	14.35
DDF-L-08	Low	31.68	DDF-M-10	Medium	10.55
DDF-L-09	Low	8.55	DDF-H-01	High	5.47
DDF-L-10	Low	2.58	DDF-H-02	High	2.59
DDF-M-01	Medium	3.44	DDF-H-03	High	5.07
DDF-M-02	Medium	51.17			

Type 2: Alder Mixed Conifer (45 acres, FMU abbreviation AMC)



The alder mixed conifer stand type is distributed widely across the property but restricted to six relatively small patches. All of the patches are associated with wetland features and are found in areas with moderate to no slope. Pure stands of red alder are rare and occur at small scales (about ½ acre). The average age for this stand type is 90 years (taken from dominant Douglas-fir trees, with a range between 73 and 120 years old) though the age of alder is likely somewhat younger. Within most patches, scattered conifers such as Douglas-fir, grand fir (*Abies grandis*), and hemlock (*Tsuga heterophylla*) were associated at low densities with the alder and often dominated with respect to canopy position and diameter. These productive areas exhibit patches of high timber volume, though recent logging capitalized on much of the merchantable volume. Over the 10-year remeasurement period for permanent plots, this stand type showed high mortality (27.3%; with 1/3 of the mortality from

alder and 2/3 of the mortality from hemlock), an average diameter increase of 11.2% and an overall increase in merchantable volume of 9.7%.

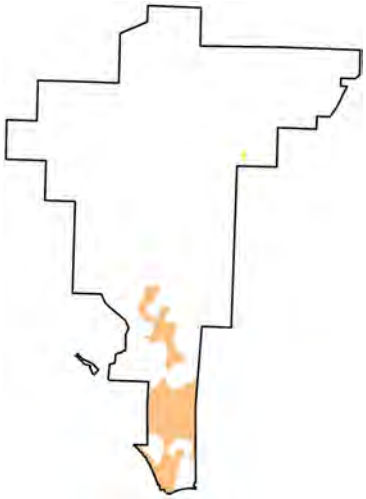
Though the total size of the six alder mixed conifer stands is only 45 acres, these are hugely important to the ecology of the Turtleback Preserve. They add nitrogen to the soil as well as substantial organic matter through the annual deposition of leaf litter and fine root sloughing. Fallen trees decay rapidly, creating soft down wood with seasonally high water content that is more rapidly colonized by decay fungi and insects comparted with conifer species. Importantly, due to large quantities of standing dead wood (i.e., snags, dead tops and limbs), these stands provide excellent quality and quantity of nesting cavities and foraging sites for birds, bats, and small mammals. These stands are often located adjacent to or surrounding wetlands and streams and are biological hot spots for insects and other invertebrates. They are also associated with high concentrations of amphibian species.

The alder mixed conifer stand type includes six unique forest management units (Table 4).

Table 4 - Alder mixed conifer FMUs

Alder Mixed Conifer (Stand Type 2 - 45 acres)					
FMU ID	**Slope**	**Acres**	**FMU ID**	**Slope**	**Acres**
AMC-L-01	Low	5.00	AMC-L-04	Low	4.02
AMC-L-02	Low	7.85	AMC-L-05	Low	7.08
AMC-L-03	Low	9.33	AMC-L-06	Low	11.78

Type 3: Douglas-fir transitional (126 acres, FMU abbreviation DFT)



The Douglas-fir transitional stand type is found bordering grasslands and dry Douglas-fir types in the southern portion of the property. This stand type was historically comprised of savanna and mixed Douglas-fir—Garry oak woodland. The recent structural change toward more closed forest conditions was driven by encroachment of Douglas-fir, likely due to lack of frequent anthropogenic fire. Most trees are young (ranging from 42 to 48 years old, with an average age of 42) and growing rapidly due to lack of competition. However, some areas have reached higher densities and are beginning to self-thin via competitive mortality. Continued conifer encroachment threatens oak woodlands and grassland communities. (Note: ages taken are representative of the younger, post-fire suppression cohorts, as no ages were taken on some of the scattered old growth trees. These older trees may reasonably be presumed to have belonged to historic stand structures that

developed under pre-European fire regimes.) Over the 10-year remeasurement period for permanent plots, this stand type showed no mortality (however, one of the plots was located in a restoration area and four of the tagged trees had been removed), an average diameter increase of 42.3% and an overall increase in merchantable volume of 64.9%.

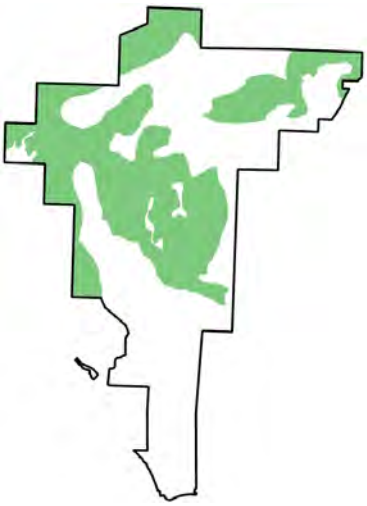
This stand type is aggregated in the south of the preserve and contains the lowest density and volume of trees. Oak woodland and native grassland restoration work is active and ongoing in these areas and management strategies for promoting these important habitats will likely dictate most management decisions in the future. However, there is a need for ecologically-based density reduction as well as individual tree release targeting both old-growth Douglas-fir and Garry oak trees. Returning captured charcoal to the soil, coupled with thinning and release treatments, would increase the carbon sequestration capacity of the stand and increase long-term resilience as well as fire safety.

The Douglas-fir transitional stand type includes six unique forest management units (Table 5).

Table 5 - Douglas-fir transitional FMUs

Douglas-Fir Transitional (Stand Type 3 - 126 acres)					
FMU ID	**Slope**	**Acres**	**FMU ID**	**Slope**	**Acres**
DFT-L-01	Low	18.52	DFT-M-02	Medium	14.73
DFT-L-02	Low	51.61	DFT-M-03	Medium	14.17
DFT-M-01	Medium	14.24	DFT-M-04	Medium	12.46

Type 4: Mesic Douglas-fir (742 acres, FMU abbreviation MDF)



This type occupies the largest area of the property and is found on a range of slopes with generally northwest to north to northeast aspects. It differs in composition from Dry Douglas-fir due to the higher frequency of grand fir, western hemlock, red alder, and western redcedar. The average age for this stand type is 99 years (taken from dominant Douglas-fir trees) though individual stands vary considerably in age, ranging from 50 to 158 years old. Recent selective logging activity was extensive yet restricted to the more easily accessible and moderately sloped portions of stand type. The small group selection style of harvesting has resulted in a fine-scaled mosaic of age classes and stand density. On steeper or less accessible sites, this stand type was logged 60-70 years ago or, in some cases, not at all. An impressive patch of old growth is found along a riparian corridor located in the central eastern portion of the property. The extreme northern portion of the stand type contains a large area

that appears to be the result of a stand-replacing fire and exhibits an 90-100 year old Douglas-fir stand of surprising uniformity. Over the 10-year remeasurement period for permanent plots, this stand type showed 9.8% mortality (predominantly grand fir, alder, and hemlock), an average diameter increase of 10.3% and an overall increase in merchantable volume of 21.4%.

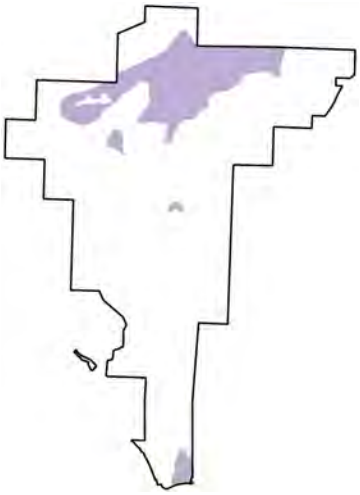
The mesic Douglas-fir stand type contains significant amounts of biomass and is the most productive type on the preserve. Logging activity was extensive in this stand type but management actions were solely focused on timber harvest and no signs of thinning have been observed.

The mesic Douglas-fir stand type includes 24 unique forest management units (Table 6).

Table 6 - Mesic Douglas-fir FMUs

Mesic Douglas-Fir (Stand Type 4 - 742 acres)					
FMU ID	**Slope**	**Acres**	**FMU ID**	**Slope**	**Acres**
MDF-L-01	Low	7.00	MDF-M-02	Medium	7.79
MDF-L-02	Low	40.30	MDF-M-03	Medium	47.43
MDF-L-03	Low	7.45	MDF-M-04	Medium	62.89
MDF-L-04	Low	3.81	MDF-M-05	Medium	12.54
MDF-L-05	Low	19.18	MDF-M-06	Medium	19.44
MDF-L-06	Low	62.78	MDF-M-07	Medium	8.94
MDF-L-07	Low	10.34	MDF-H-01	High	19.27
MDF-L-08	Low	5.66	MDF-H-02	High	24.86
MDF-L-09	Low	74.94	MDF-H-03	High	4.60
MDF-L-10	Low	117.64	MDF-H-04	High	3.29
MDF-L-11	Low	89.50	MDF-H-05	High	4.47
MDF-L-12	Low	31.04	MDF-H-06	High	12.14
MDF-M-01	Medium	44.46			

Type 5: Mesic mixed conifer (269 acres, FMU abbreviation MMC)



This type is restricted to the northern third of the property, usually occurring on moderate to steep slopes with northerly aspects. It is characterized by a greater proportion of western redcedar and/or western hemlock compared with other types. In many stands Douglas-fir dominates, but these are true mixed-conifer stands with robust second and third cohorts of shade-tolerant species such as western redcedar, western hemlock, and grand fir. The average age for this stand type is 108 years (taken from dominant Douglas-fir trees), though individual stands vary in age from 79 to 155 years old. Recent harvesting was extensive but tended to focus on higher value trees and was restricted to more accessible sites. Over the 10-year remeasurement period for permanent plots, this stand type showed 19.6% mortality (predominantly red cedar, alder, and hemlock), an average diameter increase of 12.4% and an overall increase in merchantable volume of 13.5%.

This stand type dominates portions of the northern part of the preserve with north-facing slopes. It exhibits some of the most intact old-growth forest characteristics and contains a broad mixture of conifer species. A significant part of the main access road (the North Trail) runs through this stand type and there is an urgent need for fuel reduction treatments along the road. Signs of drought stress, primarily in the form or dying cedars, are present in the eastern portions of the stand, and very dense hemlock regeneration covers many of the areas that were recently logged. Hemlock is one of the most drought-sensitive species in the preserve and these areas will likely experience significant drought or insect-induced mortality in the coming decades. These are productive and diverse stands that, with the addition of some targeted fuel reduction work along with ecologically-based density reduction, should continue to develop well towards complex old-growth conifer forests.

The mesic mixed conifer stand type includes 13 unique forest management units (Table 7).

Table 7 - Mesic mixed conifer FMUs

Mesic Mixed Conifer (Stand Type 5 - 269 acres)					
FMU ID	**Slope**	**Acres**	**FMU ID**	**Slope**	**Acres**
MMC-L-01	Low	21.46	MMC-L-08	Low	7.27
MMC-L-02	Low	16.64	MMC-L-09	Low	2.92
MMC-L-03	Low	8.39	MMC-L-10	Low	14.57
MMC-L-04	Low	4.95	MMC-M-01	Medium	86.41
MMC-L-05	Low	9.16	MMC-M-02	Medium	47.59
MMC-L-06	Low	27.51	MMC-H-01	High	4.37
MMC-L-07	Low	17.64			

Type 6: Grassland (158 acres, FMU abbreviation GRL)

The Grassland vegetation type is found throughout the preserve, predominantly on steep, rocky and, generally south-facing sites, and is associated with woodland and savanna tree species such as Garry oak and juniper. Regionally, these are vegetation types that are rare and in decline from threats that include encroachment by Douglas-fir (because of the disruption of frequent, low-intensity fires), competition from invasive grasses and other woody species, and excessive herbivory. The Land Bank's recent restoration efforts have included removal of Douglas-fir trees and invasive shrubs, seeding, and planting grasses, forbs, and acorns.

Although the many Garry oaks already released from Douglas-fir competition are showing signs of recovery, many other large and small oaks throughout the Preserve remain overtopped by conifers. The 2018 Turtleback Mountain Preserve Site Assessment prepared by the Center for Natural Lands Management outlined broad conservation goals for Garry oak and grasslands as well as specific objectives such as identifying and protecting the best remnant oak habitats, further thinning Douglas-fir trees to release both Garry oaks and prairie balds, removing Himalayan blackberry, and creating connected, protected corridors of diverse understory herbaceous communities. This forest health assessment recognizes Garry oak woodlands, savanna, and prairie as unique habitat types and seeks to increase their interconnectedness through short-, medium- and long-term management actions. Defined loosely by a combination of current canopy density and composition and estimated historic extent, they occupy a roughly 200-acre swath across the Preserve's southern and western slopes that includes some areas currently mapped as the Douglas-fir transitional stand type.

The grassland stand type includes 11 unique management units (Table 8).

Table 8 - Grassland FMUs

Grassland (Stand Type 6 - 158 acres)					
FMU ID	**Slope**	**Acres**	**FMU ID**	**Slope**	**Acres**
GRL-01	N/A	1.50	GRL-07	N/A	4.10
GRL-02	N/A	9.00	GRL-08	N/A	8.09
GRL-03	N/A	3.90	GRL-09	N/A	2.08
GRL-04	N/A	12.84	GRL-10	N/A	17.85
GRL-05	N/A	1.90	GRL-11	N/A	7.08
GRL-06	N/A	89.89			

Access

Roads and trails were a secondary factor in delineating forest management units, but greatly influence the management recommendations that follow. We identified roads and trails according to four categories: truck roads, unimproved truck roads, forest access and skid roads, and trails (Figure 4). Deer Harbor Road, a public road, also runs through or along the southern edge of the preserve.

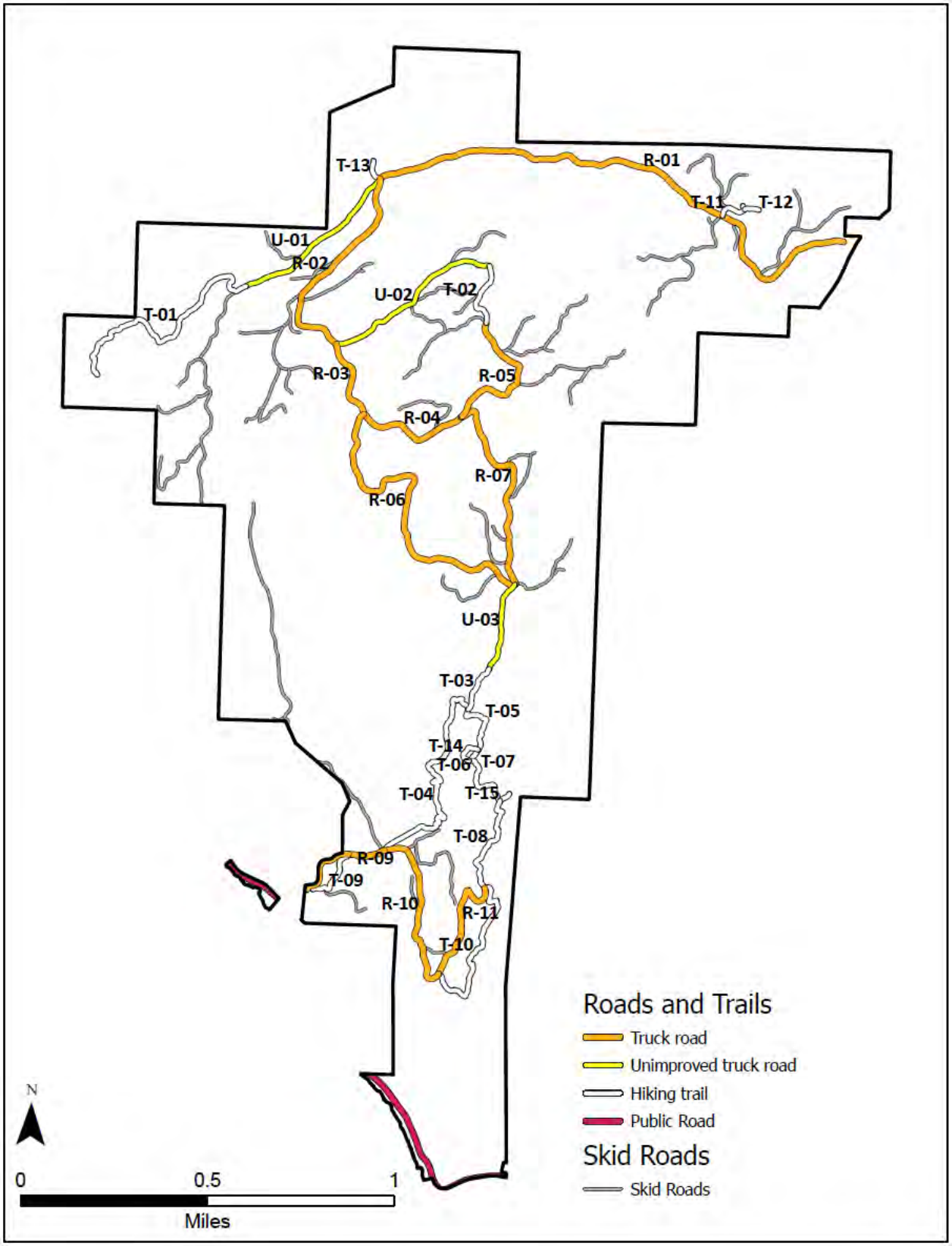


Figure 4 – Roads, trails, and skid roads, with truck roads, unimproved truck roads, and hiking trails labeled by ID number

Truck Roads

Truck roads (Table 9) are defined as existing gravel roads that have been maintained to allow vehicle access to the preserve, including powerline maintenance equipment on the south end of the preserve. These include the North Trail, the Center Loop trail, much of the Raven Ridge Trail, and the South Trail up to the Ship Peak overlook. As recently as 2005, these were maintained as part a network of hauling roads for the use of log trucks and other timber harvest equipment. The current conditions of the truck roads range from acceptable and useable to moderately degraded and at risk of significant damage due to increasing washouts and bank sloughing. Ditch clearing is urgently needed in places, along with the installation of new or upsized culverts. The current network of truck roads does not meet the standards of the Washington Department of Natural Resources Forest Practice Rules.[2]

Table 9 - Turtleback Preserve truck roads

ID	Trail Name	Use	Type	Length (Miles)
R-01	North Trail	Multi-use	Truck road	1.48
R-02	North Trail	Multi-use	Truck road	0.61
R-03	North Trail	Multi-use	Truck road	0.23
R-04	Center Loop Trail	Multi-use	Truck road	0.31
R-05	Raven Ridge Trail	Multi-use	Truck road	0.41
R-06	Center Loop Trail	Multi-use	Truck road	0.91
R-07	Center Loop Trail	Multi-use	Truck road	0.58
R-08	South Access Road	Service road	Truck road	0.17
R-09	South Trail	Hiker only	Truck road	0.10
R-10	South Trail	Hiker only	Truck road	0.47
R-11	South Trail	Hiker only	Truck road	0.34

Unimproved truck roads

Unimproved truck roads (Table 10, Figure 5) were functional at one time for use in logging operations. While they now serve as part of the hiking and/or multi-use trail network, they are wider than the Land Bank's standard 18-36-inch tread for trails and exhibit a graveled surface in some areas. The current conditions of the unimproved truck roads ranges from wide and well-maintained hiking trails (U-02 and U-03) to a drivable yet rough truck road (U-01). These roads provide important fire suppression access as well as equipment access for restoration and could be restored for management purposes by employing a variety of improvements such as heavy

[2] https://www.dnr.wa.gov/publications/fp_rules_title_222_wac.pdf

mowing, clearing down debris, installing water bar features or culverts, and minor ditching or regrading.

Figure 5 - A section of unimproved truck road U-02, the Ridge Trail

Table 10 - Unimproved truck roads

ID	Trail Name	Use	Type	Length (Miles)
U-01	Turtlehead Trail	Hiker only	Unimproved truck road	0.48
U-02	Raven Ridge Trail	Multi-use	Unimproved truck road	0.50
U-03	Ridge Trail	Hiker only	Unimproved truck road	0.25

Skid Roads

Roads mapped as skid roads (Table 11, Figure 7) are the remains of an extensive network of logging roads (some more than 100 years old and others from as recently as 2005) across the Turtleback and Turtlehead preserves. In many cases, these roads have grown back in with young trees and shrubs, and some have been affected by soil movement and washouts or nearly completely obscured by thick vegetation and fallen woody debris. We mapped skid roads that were apparent on Lidar and field checked the location of approximately 50% of them.

Additional remnant skid roads exist but were not mapped unless they were readily apparent and provide potentially important access for forest management.

Figure 6 – Skid roads can be found in a variety of conditions throughout the preserve. Here are two areas along skid road 10.

Table 11 - Skid roads

ID	Length	ID	Length	ID	Length	ID	Length
01A	0.24	09B	0.10	12	0.14	20	0.61
01B	0.11	09C	0.43	13	0.17	21	0.22
02	0.15	09D	0.17	14	0.09	22	0.06
03	0.14	09E	0.28	15	0.31	23	0.23
04	0.20	10A	0.25	16A	0.14	24A	0.16
05A	0.33	10B	0.06	16B	0.13	24B	0.11
05B	0.02	10C	0.37	16C	0.19	25	0.51
05C	0.25	10D	0.13	17A	0.33	26A	0.11
06	0.08	10E	0.07	17B	0.12	26B	0.30
07	0.29	10F	0.07	18	0.24	27	0.16
08	0.18	11A	0.19	19A	0.09	28	0.09
09A	0.22	11B	0.05	19B	0.14	29	0.07

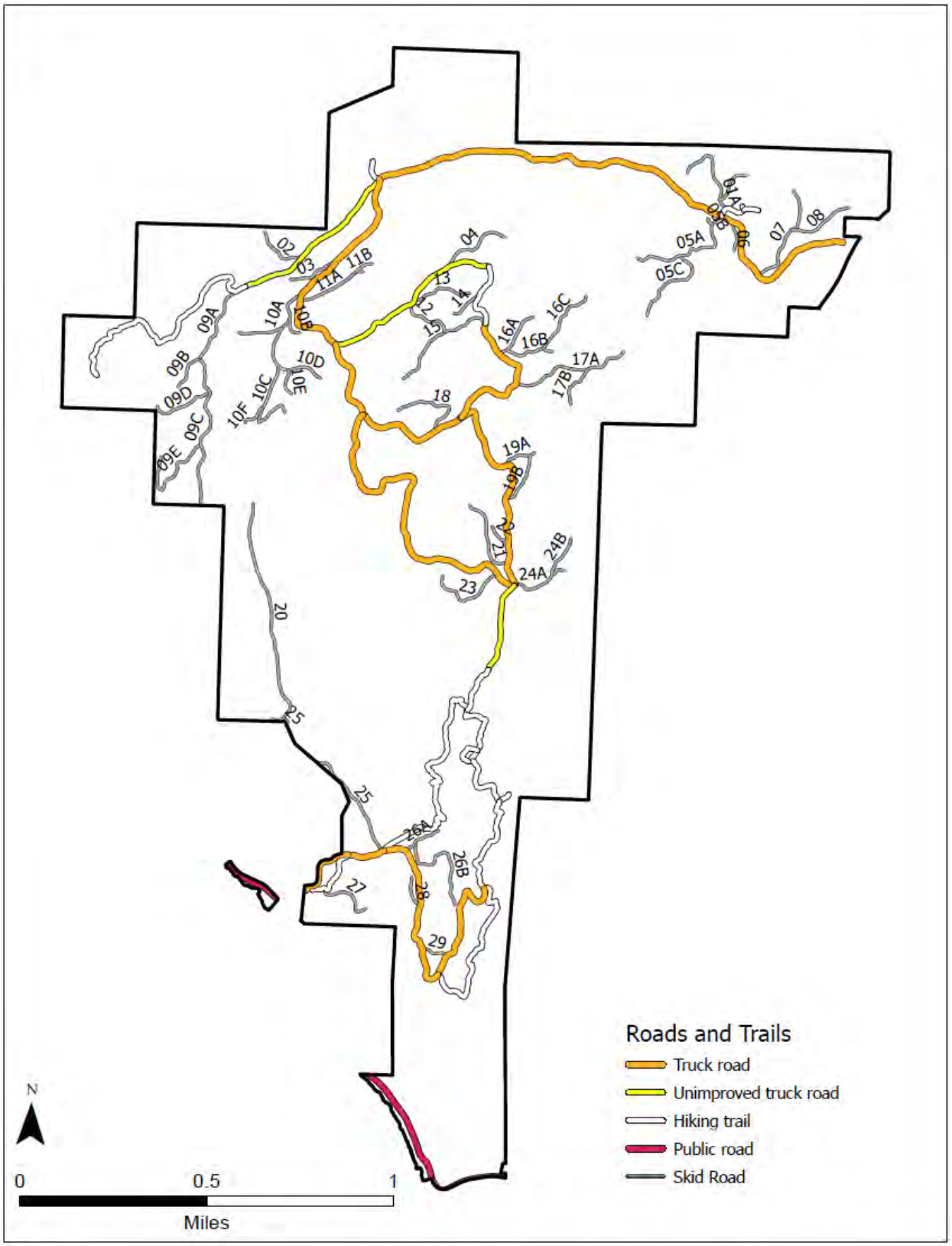


Figure 7 - Skid roads, labeled by ID number

Trails

Trails (Table 12, Figure 8) include designated and maintained footpaths that do not meet the definitions for truck roads or unimproved truck roods. These include the western part of the Turtlehead Trail, the Lost Oak Trail, the Morning Ridge Trail, various parts of the South Trail, about half of the Ridge Trail, a short section of the Raven Ridge Trail, and spur trails to several overlooks. The Land Bank standards for trail construction include an 18-36-inch tread, a natural, native surface, and sustainable location and construction. Except for part of the Raven Ridge Trail and a very short part of the North Valley Overlook trail all of the trails are designated for hiker use only.

Table 12 - Trails

ID	Trail Name	Use	Type	Length (Miles)
T-01	Turtlehead Trail	Hiker only	Trail	0.71
T-02	Raven Ridge Trail	Multi-use	Trail	0.19
T-03	Ridge Trail	Hiker only	Trail	0.13
T-04	Lost Oak Trail	Hiker only	Trail	0.71
T-05	South Trail	Hiker only	Trail	0.17
T-06	South Trail	Hiker only	Trail	0.04
T-07	South Trail	Hiker only	Trail	0.19
T-08	South Trail	Hiker only	Trail	0.30
T-09	South Trail	Hiker only	Trail	0.16
T-10	Morning Ridge	Hiker only	Trail	0.49
T-11	North Valley Overlook	Multi-use	Trail	0.09
T-12	North Valley Overlook	Hiker only	Trail	0.04
T-13	Waldron Overlook	Hiker only	Trail	0.06
T-14	South Trail Overlook	Hiker only	Trail	0.08
T-15	Ship Peak	Hiker only	Trail	0.03

MANAGEMENT RECOMMENDATIONS

Fire Safety

Lowering the risk of uncontrollable wildfire is perhaps the most important management decision affecting the protection of the unique ecology of Turtleback, as well as protecting its neighboring people and properties. As our local climate continues to experience increasing extremes in weather patterns, including more severe seasonal drought and late summer drying,

management actions that prioritize lowering the hazardous fuel loads in key areas is one of the more effective tools that managers wield. In addition, maintaining and improving access for fire suppression equipment and forest management activities are crucially important.

Shaded Fuel Breaks

The main purpose of a shaded fuel break is to create a fuel and vegetation arrangement that, in the event of a wildfire, reduces fire intensity and rate-of-spread such that it can more easily be controlled or extinguished. It also provides safer access for fire suppression work as well as emergency escape routes. The design of the fuel breaks for Turtleback in this document incorporates the use of existing roads and trails, as these features have fuel-free surfaces and provide important access for the installation and maintenance of the fuel breaks. In addition to interior roads, an effective long-term risk reduction strategy should include reducing fuel loads along the boundaries of the preserve and developing partnerships with adjoining landowners. Access to property boundaries may be difficult and each neighboring ownership will have its own set of additional challenges. The scope of this report did not include a specific evaluation of fuel loads and levels of fire risk along boundaries.

Rain Shadow proposes two classes of shaded fuel breaks. Class I has been designed for existing truck roads, unimproved truck roads, and key skid roads. Class I fuel breaks have a 50-foot width treatment zone for areas categorized as low slope (less than 35% slope) and a 75-foot width treatment zone for areas categorized as medium and high slope (greater than 35% slope). Class II fuel breaks have a fixed 20-foot width treatment zone and are designed for trails.

Figure 9 - Truck road R-01 (North Trail) through stand type 5 (mesic mixed conifer) with low-hanging limbs over the road and heavy fuel on both sides

Design

All shaded fuel breaks are designed to be installed on both sides of roads and trails and the width of the treatment zone should be measured as a *horizontal distance* from the edge of the road/trail. Shaded fuel breaks should ideally maintain a 30 to 70% canopy cover of mature trees. In areas where canopy cover is less than 30%, implementation will need to be flexible and allow for younger trees to establish and increase in size and height before the recommended treatments can be applied. Flexibility will also need to be employed in areas where treatment zones overlap with wetland and stream buffers as well as areas adjacent to active native species restoration.

Class I Shaded Fuel Breaks

Class I Low Slope (< 35% slope) shaded fuel breaks have a treatment zone of **50 feet** and Class I Medium and High Slope (>35% slope) shaded fuel breaks have a treatment zone of **75 feet**. Within these treatment zones:

- Open dense tree canopies to achieve a 60-70% canopy cover by removing low-vigor and less drought tolerant trees. Target, for removal, trees 9” DBH and smaller and preference the retention of drought and fire tolerant species (Douglas-fir, pine, and hardwood species) by removing hemlock, cedar, and grand fir.
- Reduce ladder fuels by removing small conifers (< 6” DBH), limbing lower branches on retained trees (limb to 12 vertical feet from base) and removing branches overhanging the road to a height of 20 vertical feet.
- Reduce brush type fuels by mowing or cutting (e.g., ocean spray, conifer seedlings, rose, salal, *Rubus* spp.)
- Reduce woody surface fuels by cutting and removing all fine and moderate fuel classes (<5” in diameter) that have accumulated to a height of 3” or more, leaving in place large woody debris.
- Woody debris created from removals and pruning under 5” in diameter should be chipped or converted to Bio-char via conservation burn piles or portable kilns. Managers may want to promote the creation of wildlife piles (constructed piles of logs and branches for the purpose of providing habitat for a wide number of vertebrate species) with some of the debris, especially in areas adjacent to riparian and wetland zones or in wetter forest types with less fire risk. Returning charcoal to the site should be promoted where feasible to reduce carbon emissions and improve forest soil health.
- Larger diameter logs should be left to on the site to decay in full contact with the ground.

Class II Shaded Fuel Breaks

Class II shaded fuel breaks have a treatment zone of 20 feet. Within this treatment zone:

- Reduce ladder fuels by removing small conifers (< 6” DBH), limbing lower branches on retained trees (limb to 10 vertical feet from base), and removing branches overhanging the trail to a height of 10 vertical feet.
- Reduce brush type fuels by cutting or mowing (e.g., ocean spray, conifer seedlings, rose, salal, *Rubus* spp.)
- Reduce woody surface fuels by cutting and removing all fine and moderate fuel classes (<5” in diameter) that have accumulated to a height of 3” or more, leaving in place large woody debris.
- Woody debris created from removals and pruning under 5” in diameter should be pile burned or converted to Bio-char via conservation burn piles where water is available. Managers may want to promote the creation of wildlife piles (constructed piles of logs and branches for the purpose of providing habitat for a wide number of vertebrate species) with some of the debris, especially in areas adjacent to riparian and wetland zones or in wetter forest types with less fire risk. Returning charcoal to the site should be promoted where feasible to reduce carbon emissions and improve forest soil health.
- Larger diameter logs should be left to on the site to decay in full contact with the ground.

Treatment of Slash and Debris (Best Management Practices)

The installation and maintenance of shaded fuel breaks will create substantial quantities of woody fuel that will need to be treated. These fuels will be close to access roads, providing opportunities for carbon friendly practices such as Bio-char conversion using conservation burns or mobile kilns. Also, debris could easily be chipped and trucked off site to supply fuel for future biomass power generators.

Location and Implementation

Class I shaded fuel breaks should ideally be installed on all truck roads, all unimproved truck roads, and a select number of skid roads that provide access to remote sections of the preserve. However, due to observed fuel loads, slope, and topographical position, the following roads should be prioritized for treatment (Figure 10) using a two-tiered system. Tier 1 is for immediate action that supports risk reduction and methodology testing and Tier two is for the broader application of the treatment in high-risk areas.

Tier 1 (1.88 miles):

- Truck roads: R-01 (lower section), R-03, and R-09 (.81 miles)
- Unimproved truck roads: U-02 and U-03 (.75 miles)
- Skid roads: 16B and 16C (.32 miles)

Tier 2 (4.86 miles):

- Truck roads: R-01 (upper section), R-02, R-04, R-05, R-07, and R-10 (3.38 miles)
- Skid roads 9A, 9C, 17A, and 25 (1.48 miles)

Class II shaded fuel breaks should be installed on the following trails:

- Trails T-01, T-02, T-03, and T-04 (1.75 miles)

Because of the high risk of catastrophic fire during extreme weather events and the relative inaccessibility for ground-based fire suppression equipment, the installation of a comprehensive system of shaded fuel breaks is the highest priority for the long-term protection of Turtleback and Turtlehead biological resources. As such, efforts should be made to implement these treatments as soon as possible. Tier 1 implementation should begin in late 2021 and be completed in 2022, and Tier 2 implementation should begin in 2023 and ideally be completed within 2 years. Class II shaded fuel breaks should be installed starting in 2024 and completed within two years. Maintenance, likely needed on a 4 to 6-year interval, will be important, yet will be at significantly lower cost than initial installation (see cost estimates in Appendix C: Management Cost Estimates).

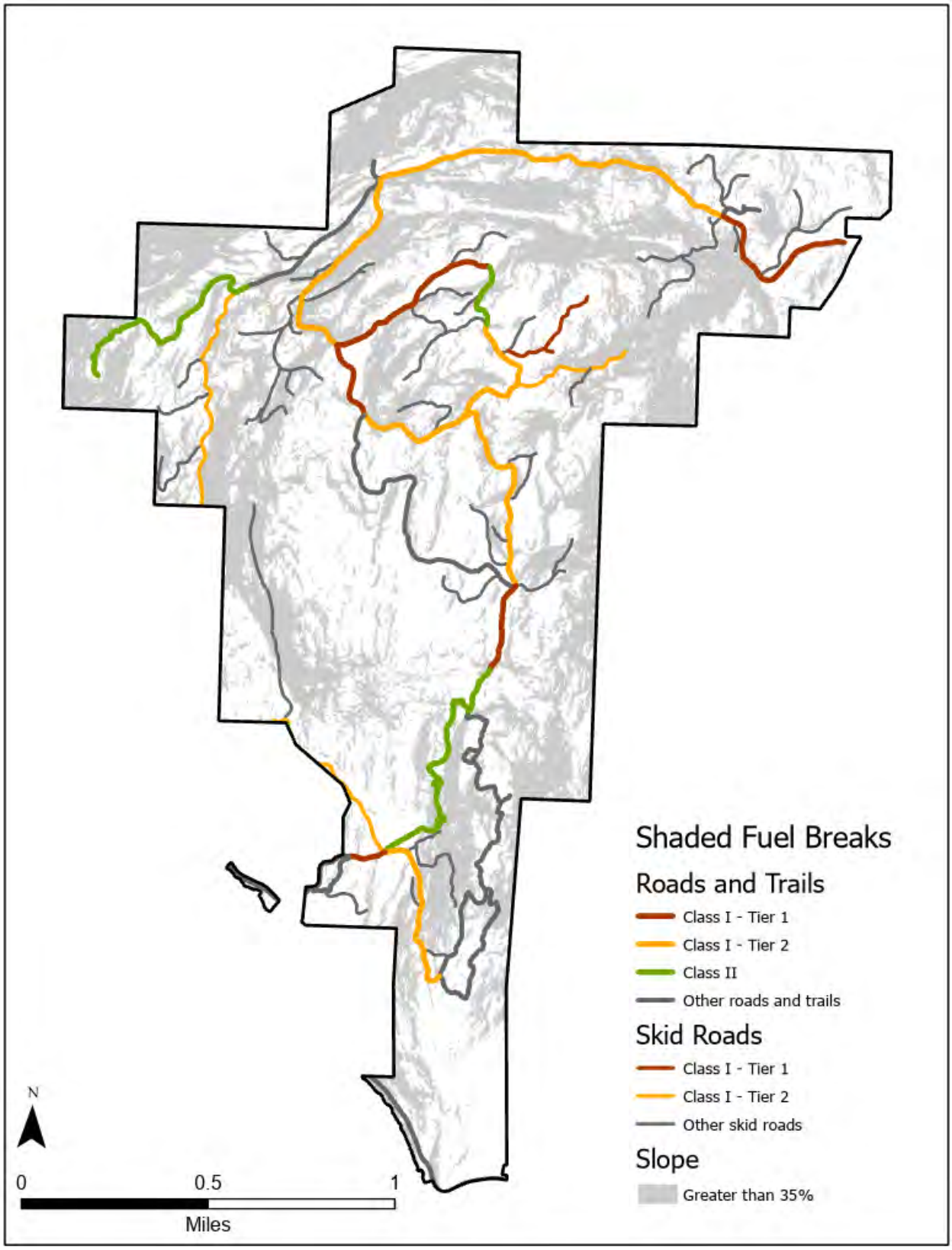


Figure 10 - Priority roads, trails and skid roads for shaded fuel breaks

Roads and Access Routes

Turtleback's road and trail network are essential for access, monitoring, restoration, and fire safety. A DNR-approved road maintenance and abandonment plan (RMAP) is required as part the Forest Practices Application, and forest roads must meet the maintenance requirements outlined in the Washington Administrative Code (WAC) section 222-24-052.[3] Under Washington's Forest Practices Rules, best management practices include minimizing new road construction, providing fish passage for all life stages, minimizing road runoff, preventing erosion, protecting stream bank stability, maintaining wetland functions, and avoiding building roads during periods of heavy rain. Prior approval from DNR may be required when constructing roads where there is risk of sediment entering water or wetlands, operating equipment near streams or other sensitive sites, or installing or replacing stream crossings. Necessary permits may include a standard Forest Practices Application/Notification and/or a Forest Practice Hydraulic Project Approval.

Truck Roads

Truck roads should be restored to functional and working conditions that will allow continued year-round access for small trucks and seasonal access for fire suppression and forestry equipment. Small trucks need to be able to have year-round access to conduct monitoring, road maintenance and storm clean-up, as well as logistical support for restoration field crews. During dryer times of the year, truck roads should be accessible by pump trucks and other fire suppression equipment as well as forestry equipment for the purpose of implementing fire hazard reduction work as well as restoration work. Restoration work may involve the use of tracked equipment (i.e., excavator) and wheeled equipment (i.e., chippers, log forwarder, equipment trailers, log trucks).

A road engineer or an experienced local expert should be consulted on how best to restore the condition of these roads and would also be the best source of cost estimates.

Unimproved truck roads

Road U-01 has signs of significant soil movement west of skid road 02. This section is probably not worth restoring to a drivable roadbed and, west of the junction, should transition to hiking trail only. U-2 and U-3 provide important access to FMU's with recommended restoration treatments and should be improved to a similar condition as recommended for truck roads.

[3] https://apps.leg.wa.gov/wac/default.aspx?cite=222-24-052

Figure 11 - Restoring unimproved truck roads to truck road status will require upgraded culverts in several locations. Here where unimproved truck road U-03 (the Ridge Trail) crosses Drainage E, a culvert is installed the road bed will need to be widened. Unimproved truck road U-02 (the Raven Ridge Trail) will also need improved stream crossing at Drainages C, D, and E.

Skid Roads

The main utility in these features, other than the select few recommended for shaded fuel break installation, is for occasional use during forestry or restoration work. Because the timing and the exact type of use has not been determined, there are no recommended improvements at this time.

Trails

In addition to their recreational use and appeal, Turtleback and Turtlehead's trails provide important access for restoration crews and may be useful in fire suppression efforts. Trails should continue to be managed according to Land Bank and San Juan Preservation Trust standards and in accordance with public access goals set forth for the Turtleback and Turtlehead preserves.

Stands and Forest Management Units (FMU's)

As discussed above, the six stand type designations (including grasslands) were divided into 81 individual management units and given unique IDs. Based on the conditions of the stand types, variations slope, and constraints around accessibility, five general restoration treatments have

been developed. A general overview of management recommendations for the grasslands FMUs is covered in the Habitats of Local Importance section later in this document.

Treatment Type I: Fire Protection and Monitoring (Ecological Reserves)

Management actions for Treatment Type I are limited to fire protection measures such as fuel breaks and road improvements. Functionally, the FMUs selected for this treatment will be treated as ecological reserves with little or no intervention. The Treatment Type I FMUs include all of the alder mixed conifer (AMC) stands, as these stands are of small overall size, are adjacent or surrounding sensitive wetland features, and are important habitat for a host of plant and animal species:

- **Stand 2:** AMC-L-01, AMC-L-02, AMC-L-03, AMC-L-04, AMC-L-05, AMC-L-06

FMUs with High slope and poor access:

- **Stand 1:** DDF-H-01, DDF-H-02
- **Stand 4:** MDF-H-01, MDF-H-02, MDF-H-04, MDF-H-05, MDF-H-06
- **Stand 5:** MMC-H-01

FMUs with Medium and Low slope with very poor access:

- **Stand 1:** DDF-M-01, DDF-M-06
- **Stand 4:** MDF-L-01, MDF-M-02
- **Stand 5:** MMC-L-09, MMC-M-01

The total acreage of the combined 20 Type I (Ecological Reserve) FMUs is 266.9.

Treatment Type II: Ecological Thinning Treatment with Ground-Based Equipment

This treatment is designed to improve stand vigor, drought resiliency, and increase old-growth characteristics using low-impact, ground-based mechanized equipment. The treatment involves two entries per FMU, spaced approximately 20 years apart. This is based on the 2010 Biomass Assessment and the results of the 50-year growth simulations. The growth modeling concluded that the best silvicultural treatment for maximizing carbon storage and tree growth was to apply two low-volume harvest scenarios, spaced 20-25 years apart. The removal volumes have been adjusted somewhat to account for growth since 2010 and to support a general increase in vigor and resiliency through increased tree spacing. This holds true for all stand types. The FMUs recommended for treatment via ground-based equipment must have a *low* slope category rating and adequate access. The following FMUs should be prioritized for treatment using a two-tiered system. Tier 1 is for immediate action that supports increased stand resiliency and methodology testing, while Tier two is for the broader application of the treatment:

Tier 1:

- **Stand 1:** DDF-L-03, DDF-L-07

Tier 2:

- **Stand 1:** DDF-L-01, DDF-L-02, DDF-L-05, DDF-L-06, DDF-L-08
- **Stand 4:** MDF-L-02, MDF-L-03, MDF-L-04, MDF-L-05, MDF-L-06, MDF-L-07, MDF-L-08, MDF-L-09, MDF-L-10, MDF-L-11, MDF-L-12
- **Stand 5:** MMC-L-01, MMC-L-02, MMC-L-03, MMC-L-05, MMC-L-06, MMC-L-07, MMC-L-08, MMC-L-10

The total acreage of the combined 26 Restoration Treatment Type II FMUs is 775.1 (Tier 1 is 61.29, Tier 2 is 713.85).

Low impact ground-based equipment includes tracked shovel, tracked harvester/processor, and forwarder. Ground based yarding systems that drag logs on the ground will not be permitted due to soil disturbance; log forwarders that load logs onto an elevated bunk or shovels are the only approved ground-based yarding systems.

Slash and all boles of felled stems must be removed from the site or processed to limit fuels and reduce the risk of unmanaged, high-severity fire. The exception is for coarse woody debris (CWD) recruitment (see Table 13) and in-stand Bio-char processing. Also, modest quantities of post-treatment slash is allowable in wetter stand types (MDF, MMC) as these stands have higher decay rates and decomposing slash will contribute small amounts of nutrients to the soil (see Table 14 for allowable slash concentrations for each stand type). Ground based yarding equipment has the potential to efficiently move slash to processing locations for scaled-up Bio-char processing or large-scale chipping operations. Restoration thinning should follow the recommended volume removal targets as well as post-treatment tree density targets listed for each stand in Table 15.

Table 13 - CWD and snag recruitment recommendations by stand type. Note, timing of recruitment coincides with restoration treatment

Stand Type	CWD Recruitment	Snag Recruitment*
DDF	15/acre; >8” tip dia; 20’+ length; any species	4/acre; >16”DBH; any conifer
AMC	25/acre; >8” tip dia; 20’+ length; any species	6/acre; >16”DBH; any conifer
DFT	5/acre; >8” tip dia; 20’+ length; any species	2/acre; >16”DBH; any conifer
MDF	25/acre; >8” tip dia; 20’+ length; any species	6/acre; >16”DBH; any conifer
MMC	30/acre; >8” tip dia; 20’+ length; any species	6/acre; >16”DBH; any conifer

**Snag recruitment densities based on local stand reconstruction data (Waldron Island CAP, 2005) and extensive experience with similar SJI stand types (C. Sprenger).*

Table 14 - Allowable slash concentration depth and percent cover

Stand Type	Allowable Slash Concentrations - Depth	Percent Cover
DDF	5 inches	4/acre; >16”DBH; any conifer
AMC	-	-
DFT	5 inches	<5%
MDF	10 inches	<20%
MMC	30/acre; >8” tip dia; 20’+ length; any species	6/acre; >16”DBH; any conifer

Table 15 – First and stand entry restoration thinning volume and density targets by stand type

FIRST ENTRY RESTORATION THINNING			
Stand Type	Volume to Remove (%, *mbf/*acre*)*)	Pre Rx Density (TPA)	Post Rx Density (TPA)
DDF	15%, 1.5 *mbf*	140-180	90-110
AMC	-	-	-
DFT	20-30%+, 1 *mbf*	80-110	40-55*
MDF	20%, 5.5 *mbf*	160-200	130-150
MMC	15%, 3 *mbf*	180-220	140-160
SECOND ENTRY RESTORATION THINNING			
Stand Type	**Volume to Remove (%, *mbf/*acre*)*)**	**Pre Rx Density (TPA)**	**Post Rx Density (TPA)**
DDF	25%, 6.5 *mbf*	80-100	50-60
AMC	-	-	-
DFT	20-30%+, 4 *mbf*	40-50	20-30*
MDF	25%, 7.5 *mbf*	120-140	90-120
MMC	20%, 5.5 *mbf*	130-150	110-130
**Tree density may vary considerably due to oak and grassland restoration work in this stand type.*			

Treatment Type III: Ecological Thinning Treatment with Specialized Equipment

This treatment is designed to improve stand vigor, drought resiliency, and increase old-growth characteristics using low-impact specialized equipment such as semi-suspension cable yarding systems or forwarder type systems that operate on steeper slopes. The treatment involves two entries per FMU, spaced approximately 15 years apart. Therefore, the FMUs recommended for this treatment have a low or medium slope category rating and adequate access. The following FMUs should be prioritized for treatment using a two-tiered system. Tier 1 is for immediate action that supports increased stand resiliency and methodology testing, while Tier two is for the broader application of the treatment):

Tier 1:

- **Stand 1:** DDF-M-05

Tier 2:

- **Stand 1:** DDF-L-04, DDF-M-02, DDF-M-03, DDF-M-04, DDF-M-07, DDF-M-09, DDF-M-10
- **Stand 4:** MDF-M-01, MDF-M-03, MDF-M-04, MDF-M-06, MDF-M-07
- **Stand 5:** MMC-M-02

The total acreage of the combined 13 Restoration Treatment Type III FMUs is 385.7 (Tier 1 is 31.47, Tier 2 is 354.26).

Specialized equipment for this treatment on steeper slopes includes semi-suspension cable yarding systems, full suspension cable systems, and forwarder systems capable of operating on slopes above 35%. These are the only approved yarding systems.

Slash and all boles of felled stems must be removed from the site or processed to limit fuels and reduce the risk of unmanaged, high-severity fire. The exception is for coarse woody debris (CWD) recruitment (see Table 13) and in-stand Bio-char processing. Also, modest quantities of post-treatment slash is allowable in wetter stand types (MDF, MMC) as these stands have higher decay rates and decomposing slash will contribute small amounts of nutrients to the soil (see Table 14). Slash should be scattered as opposed to piled. Cable suspension yarding equipment has the potential to efficiently move slash to processing locations for scaled-up Bio-char processing or large-scale chipping operations. Whole-tree yarding with these systems can be very efficient. Cable suspension yarding equipment has the potential to efficiently move slash to processing locations for scaled-up Bio-char processing or large-scale chipping operations. Whole-tree yarding with these systems can be very efficient.

Restoration thinning should follow the recommended volume removal targets as well as post tree density targets listed for each stand in Table 15.

Treatment Type IV: Ecological Thinning Treatment with Hand Crews

This treatment is designed to improve stand vigor, drought resiliency, and increase old-growth characteristics using low-impact hand crews allowing for restoration treatments on steeper ground and in areas with limited access. The treatment involves two entries per FMU, spaced approximately 15 years apart. The FMUs recommended for this treatment have a low, medium, or high slope category rating and include areas with moderate to challenging access. The following FMUs should be prioritized for treatment using a two-tiered system. Tier 1 is for immediate action that supports increased stand resiliency and methodology testing, and Tier two is for the broader application of the treatment:

Tier 1:

- **Stand 1**: DDF-H-03
- **Stand 3:** DFT-L-01, DFT-M-01

Tier 2:

- **Stand 1:** DDF-L-09, DDF-L-10, DDF-M-08
- **Stand 3:** DFT-L-02, DFT-M-02, DFT-M-03, DFT-M-04
- **Stand 4:** MDF-H-03, MDF-M-05
- **Stand 5:** MMC-L-04

The total acreage of the combined 12 restoration treatment Type IV FMUs is 170.58 (Tier 1 is 37.83, Tier 2 is 132.75).

Hand crews, by their nature, are very low impact. Hand crews will fell trees, process limbs, and process slash. All logs larger than 5" diameter at the tip will be left on the forest floor to decay.

All slash must be processed to limit fuels and reduce the risk of unmanaged, high-severity fire. Modest slash, distributed as opposed to piled, is allowable in wetter stand types (MDF, MMC) as these stands have higher decay rates and decomposing slash will contribute small amounts of nutrients to the soil (see Table 14). On-site Bio-char processing, likely conservation-type burns or portable flame cap kilns should be used. In remote sites where water access is not obtainable, conventional small pile burning will be the preferred method of slash reduction.

Restoration thinning should follow the recommended volume removal targets as well as post tree density targets listed for each stand in Table 15.

Treatment Type V: Targeted Canopy Release

This treatment is designed to preserve old-growth Douglas-fir and isolated Garry oak trees through targeted canopy release cutting using hand crews. This work has been on-going on parts of Turtleback since 2011. These techniques could be more broadly applied to include all of the stand types with a greater focus on old-growth Douglas-fir. Because of the wide distribution and low density of these features, the first step would be to expand the oak census work to include old-growth Douglas-fir. We recommend conducting an old-growth Douglas-fir census and mapping project soon (within the next 2 years) as some of these valuable trees are in poor condition due to loss of lower branches and overtopping. With comprehensive mapping and a system for qualitative assessment, a strategic work plan can be developed for individual tree canopy release treatments. We recommend using conservation crews or contractors for these projects.

Table 16 - Summary of total acreage for each treatment, by stand type

Stand Type	Rx I	RX II	RX III	RX IV	RX V
1 - Dry Douglas-Fir	49.35	189.85	154.98	22.76	TBD
2 - Alder Mixed Conifer	45.05				TBD
3 - Douglas-Fir Transitional				125.73	TBD
4 - Mesic Douglas-Fir	78.82	462.64	183.16	17.14	TBD
5 - Mesic Mixed Conifer	93.70	122.64	47.59	4.95	TBD
Total	266.92	760.57	375.18	195.71	TBD

Tree Selection

Tree selection for removal under Treatment Types II, III, and IV will be focused on achieving the following objectives:

- Increasing overall stand vigor and growth
- Increasing resiliency to climate change through species selection and density reduction, and
- Lowering the risk of stand replacing wildfire through fuels reduction.

Following the volume and density targets for each stand type in Table 15, use the following criteria for marking removal trees:

- Select trees from the lower half of the diameter distribution
- Select trees with percent live crown below 20%
- Select a greater representational proportion of shade tolerant trees (in order of least to most drought tolerant = hemlock < grand fir < western redcedar)

Timing

To phase in the work, we are recommending spreading out the initial silvicultural treatments over an 8-year span. Tier 1 priority projects, which were selected based on ecological factors, size, location, as well as methodology testing, should be conducted as soon as possible or in the next two years (i.e., 2022 and 2023). Tier 2 priority projects should be implemented starting the year following the completion of Tier 1 (2024). In general, each stand type will have a recommended two-year work window. For the best probability of avoiding excessive tree stress and mortality, we strongly recommend focusing restoration efforts in this order:

- All Tier 1 projects, 2022-2023
- Tier 2 projects, phase 1: Douglas-fir Transitional (DFT, Stand 3), Dry Douglas-fir (DDF, Stand 1), and Grassland restoration, 2024-2025
- Tier 2 projects, phase 2: Mesic Douglas Fir (MDF, Stand 4), 2026-2027
- Tier 2 projects, phase 3: Mesic Mixed Conifer (MMC, Stand 5), 2028-2029

Steps for Implementation

All or part of the activities identified below may be carried out by either Land Bank Staff or a qualified forest management/restoration consultant.

- Flag or otherwise mark project boundaries.
- Cruise the identified FMU unit(s) to determine current conditions.
- Estimate the size and number of stems to be cut, the volume of material to be removed from the site, pathways for biomass removal and processing, and project costs (see Management Cost Estimates in Appendix C).
- Complete an inventory of roads/existing skid trails that can be used to access the project area, Flag and GPS their locations (or reference Land Bank GIS Database) and determine the nature and estimated cost of any necessary improvements. This inventory should also identify an appropriate location for landings and log decks.
- Prepare a map of the project area, access roads, existing skid trails and proposed landings.
- Submit Forest Practices Application to Washington DNR, Forest Practices Division. Consider a long-term application as these permits are valid for 15 years and are more comprehensive in scope. Secure permit before implementing project.
- Work with the San Juan County Legal Department to translate the silvicultural prescription into a contract.
- Mark all removal trees with paint.
- Prepare contract and bid information package containing silvicultural prescription and maps of project areas.
- Solicit bids.
- Notify public and develop safety plan for conducting operations.
- Implement project.

Public Access, Safety, and Education

Because the Turtleback Mountain and Turtlehead Preserves are popular recreation spots for visitors to the island and locals alike, maintaining public access and promoting public safety during forest management activities will be critical. Additionally, some of the suggested management activities may initially seem unpalatable to members of the public and other stakeholders. Public education and outreach via newsletters, press releases, the website, social media, and online or in person “town halls” and/or Q&A sessions with staff and local experts will likely be necessary to address concerns and increase support. Emphasizing the ecological reasons for certain management strategies and the focus on forest health and climate change resiliency along with public safety will likely increase support.

During management activities involving vehicles, machinery, and road/trail maintenance, work should ideally be scheduled during lower-use periods when possible, realizing that some work during busier times may be unavoidable given seasonal weather patterns and the desire to minimize impacts to sensitive soils during wetter parts of the year. Signage at trailheads and in the vicinity of work areas will be necessary to keep visitors safe and informed. Volunteer "Trailhead Hosts" could also be employed to greet visitors and provide educational information about ongoing management. Spacing work out geographically and temporally would also reduce disruption to public access and the visitor experience.

Streams, Wetlands, and other Ecologically Significant Areas

Turtleback's streams and wetlands are described thoroughly in the *Turtleback Mountain Preserve Wetland & Stream Inventory and Amphibian Survey*, prepared by Rozewood Environmental Services, Inc. in July 2008. However, the Rozewood report only covers the original Turtleback Mountain Preserve and does not include either the recent addition to Turtleback or the Turtlehead Preserve. For this report and to inform our management recommendations, Rain Shadow re-digitized the wetlands layer in ArcGIS, as the shapefile provided by the Land Bank included wetland features drawn as lines and not polygons. We added one additional wetland in the Turtlehead preserve based on the county's "possible non-tidal wetlands layer," and we updated the Wetlands attribute table to match Table 1: Wetland Summary from the Rozewood report (page 7). Based on county Fish and Wildlife Conservation areas maps, we also added an additional stream segment in the Turtlehead Preserve to the streams layer and updated the attribute table to match Table 2: Stream Summary from the Rozewood report (page 23). See Figure 12.

Turtleback's wetlands and streams are an important part of the forest ecosystem, providing wildlife habitat, protecting water quality, and contributing to plant and animal species diversity. They also contribute to the critical surface and groundwater resources on surrounding private and public lands. Damage to streams and wetlands from forest management activities such as road building and harvesting can have significant negative impacts, so steps should be taken to protect these resources through the use of buffers and equipment limitation zones.

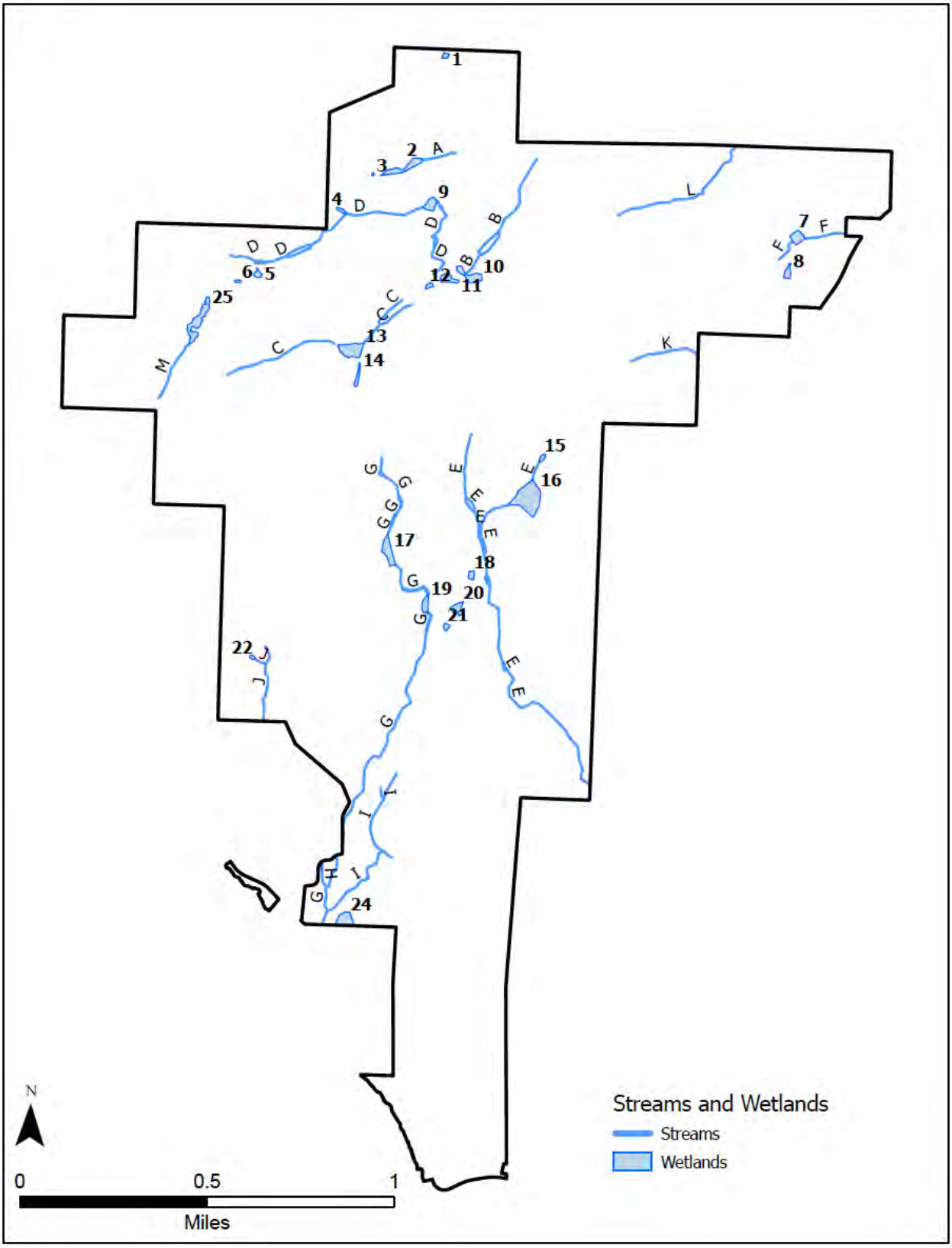


Figure 12 - Streams (letters) and wetlands (numbers) with labels corresponding to the Rozewood report and GIS layers

Wetlands

The Rozewood report inventoried, described, and classified 24 wetlands on the Turtleback Mountain Preserve and found many of them to have moderate to high habitat function. Rozewood documented four species of amphibians within the preserve, including long-toed salamanders (*Ambystoma macrodactylum*), rough-skinned newts (*Taricha granulosa*), red-legged frogs (*Rana aurora*), and Pacific chorus frogs (*Pseudacris regilla*). Amphibian surveys found significant breeding activity in the spring of 2007, particularly in wetlands 1, 2, 10, 13, and 20. Wetland 16 is the largest wetland in the preserve, with the largest organic soil deposits and a one-acre stand of lodgepole pine growing in its central core. Though this wetland was not determined to qualify as a bog, it may qualify as a mature forested wetland if trees older than 80 years old can be confirmed.

Wetlands are defined and regulated in San Juan County by provisions in the Unified Development Code Title 18 San Juan Code (SJCC) sections 18.35.085 through 18.35.105,[4] and Rozewood used the county wetland categories at the time of that report. In some cases, wetlands and streams may also be regulated under the federal Clean Water Act administered by the US Army Corps of Engineers, or by the Washington state Water Pollution Control Act and/or Shoreline Management Act administered by the Washington State Department of Ecology. For forest management purposes, wetlands fall under Washington's Forest Practices Rules and are defined slightly differently than in the SJCC.[5] Forest practices rules describe a Type A wetland as an area of at least one-half acre (one-quarter acre for forested and non-forested bogs) covered by water seven consecutive days between April 1 and October 1. A Type B wetland is an open area of one-quarter acre or more that is vegetated with water-tolerant plants and/or shrubs, and a Forested Wetland is a wetland with a tree crown closure of 30 percent or more, if trees are mature. Wetland Management Zones (WMZs) are determined based on the size and type of the wetland. Forest practices rules specify a maximum, minimum and average width for WMZs, measured horizontally from the wetland edge or point where a non-forested wetland becomes a forested wetland (Table 17). While some harvesting is allowed within the WMZ, the rules specify a certain number and size of leave-trees per acre (Table 18) and ground-based harvesting systems may not be used within the minimum WMZ.

[4] https://www.codepublishing.com/WA/SanJuanCounty/html/SanJuanCounty18/SanJuanCounty18.html
[5] https://www.dnr.wa.gov/publications/fp_rules_ch222-16wac.pdf

Table 17 - Wetland Management Zone (WMZ) width by wetland size and type for Western Washington

Wetland Type	Wetland size	Max. WMZ	Average WMZ	Min. WMZ
A (including bogs)	>5 acres	200’	100’	50’
A (incl. bogs)	0.5 – 5 acres	100’	50’	25’
A (bogs only)	0.25 – 0.5	100’	50’	25’
B	>5 acres	100’	50’	25’
B	0.5 – 5	Not required		25’
B	0.25 – 0/5	Not required		
Forested	No WMZ required, low impact harvesting allowed.			

Table 18 - WMZ leave-tree size and number requirements per 1,000 linear feet of wetland boundary

Size	100’ WMZ: 172 Trees	50’ WMZ: 86 Trees	25’ WMZ: 43 Trees
6” DBH	115	57	29
12” DBH	46	23	11
20” DBH	11	6	3

Streams

Rozewood identified and mapped 12 stream drainages, including four “major,” six “intermediate,” and two “minor” drainages. We added an additional drainage in the Turtlehead Preseve to the inventory based on county maps of fish and wildlife habitat conservation areas, but we did not ground-truth the location of this drainage. All of Turtleback and Turtlehead’s streams are considered type “Ns” streams—non-fish, seasonal streams—according to the current Washington Department of Natural Resources Forest Practices water type classifications.[6]

Under Washington’s Forest Practices Rules, streams may require Riparian Management Zones (RMZs) depending on the type of stream. As currently classified, Turtleback’s Ns streams do not require buffers; however, there is a 30-foot equipment limitation zone on either side of the stream, measured horizontally from bank-full width. Should any streams ultimately be determined to be type Np (non-fish perennial) or F streams, they would require RMZ buffers based on stream type and site class according to the Forest Practices Rules. Np streams have a 30-foot equipment limitation zone (ELZ) like Ns streams and may also require additional RMZs based on length and distance from any F streams they flow into.

[6] https://www.dnr.wa.gov/forest-practices-water-typing

Habitats of Local Importance

The San Juan County Code's Critical Areas Ordinance identifies several "habitats of local importance" with additional protection requirements and recommendations (section 18.35.135, part C). Several of these habitats can be found within the Turtleback and Turtlehead Preserves, including Garry Oak Woodlands, Herbaceous Balds and Bluffs, and West Side Prairie.

Garry Oak Woodlands

Turtleback is well known for having some of the best remaining Garry oak habitat in the San Juan islands. In addition to the namesake Garry oaks, this habitat can support a variety of rare wildflowers, butterflies, and native grasslands, and other species.

The SJCC recommends minimizing disturbance in areas with Garry oak and its associated species and removing Douglas fir and other conifers to allow adequate sunlight for oak woodland areas. When disturbance is unavoidable, the area should be replanted with Garry oak, native grasses, and wildflowers.

Herbaceous Balds and Bluffs

Herbaceous balds and bluffs are located on steep, exposed slopes with shallow soils and few trees. They support communities of plants adapted to the shallow soil and seasonally dry conditions, including native grasses, herbaceous plants, dwarf shrubs, mosses and lichens, and prickly pear cactus. This habitat can support rare plant species that are absent from other natural communities and is the preferred habitat of the Taylor's checkerspot butterfly, a listed species.

Disturbance of herbaceous balds and bluffs should be avoided during management activities.

West Side Prairie

West side prairie habitats support native flowering plants such as Camas and native grasses, including *Danthonia californica* and *Festuca rubra*. This habitat generally comprises uncultivated meadows and fallow fields with few trees.

Disturbance of native grasslands and Camas prairies should be avoided or mitigated by replanting suitable areas with native grasses and wildflowers.

Management recommendations

Streams and Wetlands

Wetlands in the Rozewood report were classified according to the 2004 Wetland Rating System for Western Washington, so some classifications may have changed according to the revised

Washington State Wetland Rating System for Western Washington, updated in 2014.[7] As previously mentioned, WA Forest Practices Rules also use a slightly different wetland classification system.

Prior to any management activities near streams or wetlands, the Land Bank could consider working with a qualified wetland professional to confirm or update wetland classifications and stream ratings and to ensure that proposed activities comply with all current federal, state, and local regulations and Washington's Forest Practices Rules. It is also possible that the Rozewood study and our field work may not have found and mapped all streams and wetlands present in the Turtleback and Turtlehead preserves, and stream channel migration may occur anytime. New wetlands and streams should be documented and added to the existing GIS database, and conditions "on the ground" should supersede maps and documented features when it comes to making management decisions.

Road maintenance and/or the construction of any logging roads or landings will present the highest potential for impacts to streams and wetlands, especially given the number of stream crossings and the proximity of roads and trails to wetlands (Figure 13). Several wetlands along roads and trails (2, 10, 13) are known to have high habitat function and significant amphibian breeding activity, so timing management activities (road maintenance and forestry treatments) near these wetlands to avoid the prime breeding season (January through May) is preferred. Wetland 16—the largest wetland in the preserve at three acres and a category I wetland that may qualify as a mature forested wetland—and its associated drainage (E) are also located near a truck road (R-07) in FMU MDF-L-10, a large mesic Douglas-fir unit, where ecological thinning treatment with ground-based equipment is recommended. In this case, careful adherence to buffers will minimize potential impacts to the wetland.

Because many streams flow near roads and trails, land managers should be aware of the potential for stream channel migration, erosion, and sedimentation that could ultimately result in the need to relocate a road or a trail. Even a single tree blown down in just the right spot could alter the course of a stream and lead to erosion and damage. Armoring and riprap should be avoided unless absolutely necessary for the preservation of critical access roads.

Properly sized, installed, and maintained culverts are crucial to allowing streams to flow as naturally as possible. If the Land Bank does not currently have a complete culvert inventory, including size, location, and any current or potential maintenance needs, gathering this information would be a useful step prior to beginning any recommended road maintenance within the preserve. Culverts along major roads (truck roads) should also be inspected in the fall before the rainy season and may also need to be checked after intense storm events. If any

[7] https://apps.ecology.wa.gov/publications/documents/1406029.pdf

roads are going to be decommissioned or abandoned, existing culverts should be removed to allow for the unimpeded flow of water.

Any areas near streams and wetlands that are disturbed by the construction of roads or trails or during forestry management activities should be re-seeded or re-vegetated with native species to prevent the introduction of invasive species. Additionally, timing additional wetland management activities such monitoring and removal of invasive species to occur while other forest management is taking place in the same area may allow for increased efficiency and lower costs.

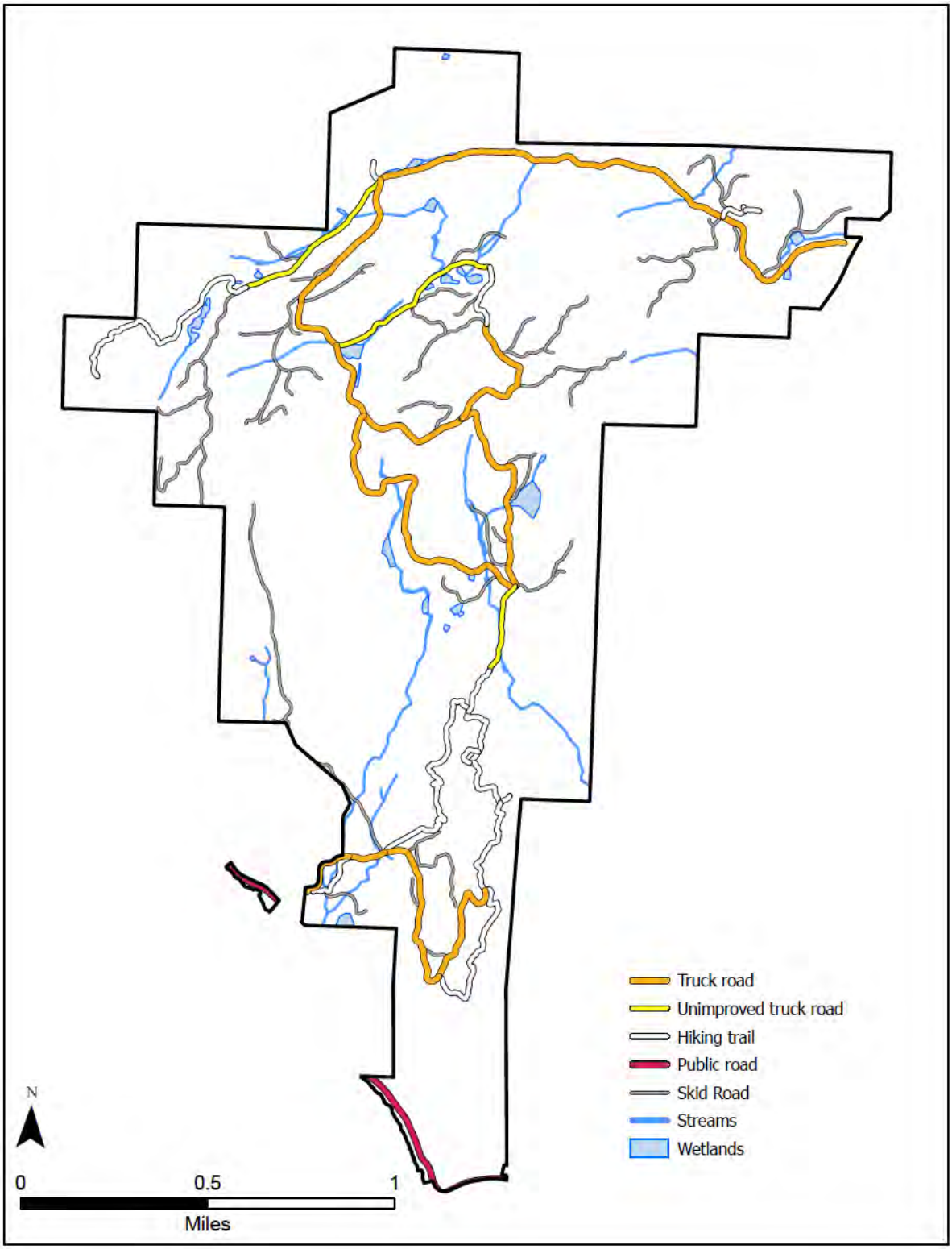


Figure 13 - Streams, wetlands, roads, and trails

Habitats of Local Importance

Garry oak habitat restoration has been ongoing within the Turtleback Mountain preserve since the Land Bank's acquisition of the property and should continue alongside other forest management activities.

Turtleback's herbaceous balds and bluffs and west side Prairie habitats have been degraded to various degrees by the presence of invasive species and encroachment from conifers. In the herbaceous bald areas in the northeast part of the preserve (FMUs GRL-01, GRL-02, GRL-03, and GRL-05) restoration work can include the removal of small-diameter conifers and planting of native forbs. Here, the focus should be on preventing further encroachment, as it is difficult and costly to restore balds after complete succession to forest. To the extent possible, forest management activities in nearby FMUs, including road and trail construction and maintenance, thinning, etc. should be planned carefully in the vicinity of balds, bluffs, and prairie habitat to avoid disturbing soils and creating prime sites for non-native plants to establish and spread.

In the southern part of the preserve, Land Bank staff have conceptualized a mosaic of Garry oak woodland, savanna, and prairie habitat that can be restored through a combination of thinning, snag creation, planting, and potentially, controlled burning (Figure 15). This work would not involve removing all of the patches of dense conifer forest, but rather increasing connectivity among and between these rare and significant remnant habitat types.

Figure 14 - A Garry oak along the Morning Ridge trail in the southern part of the preserve.

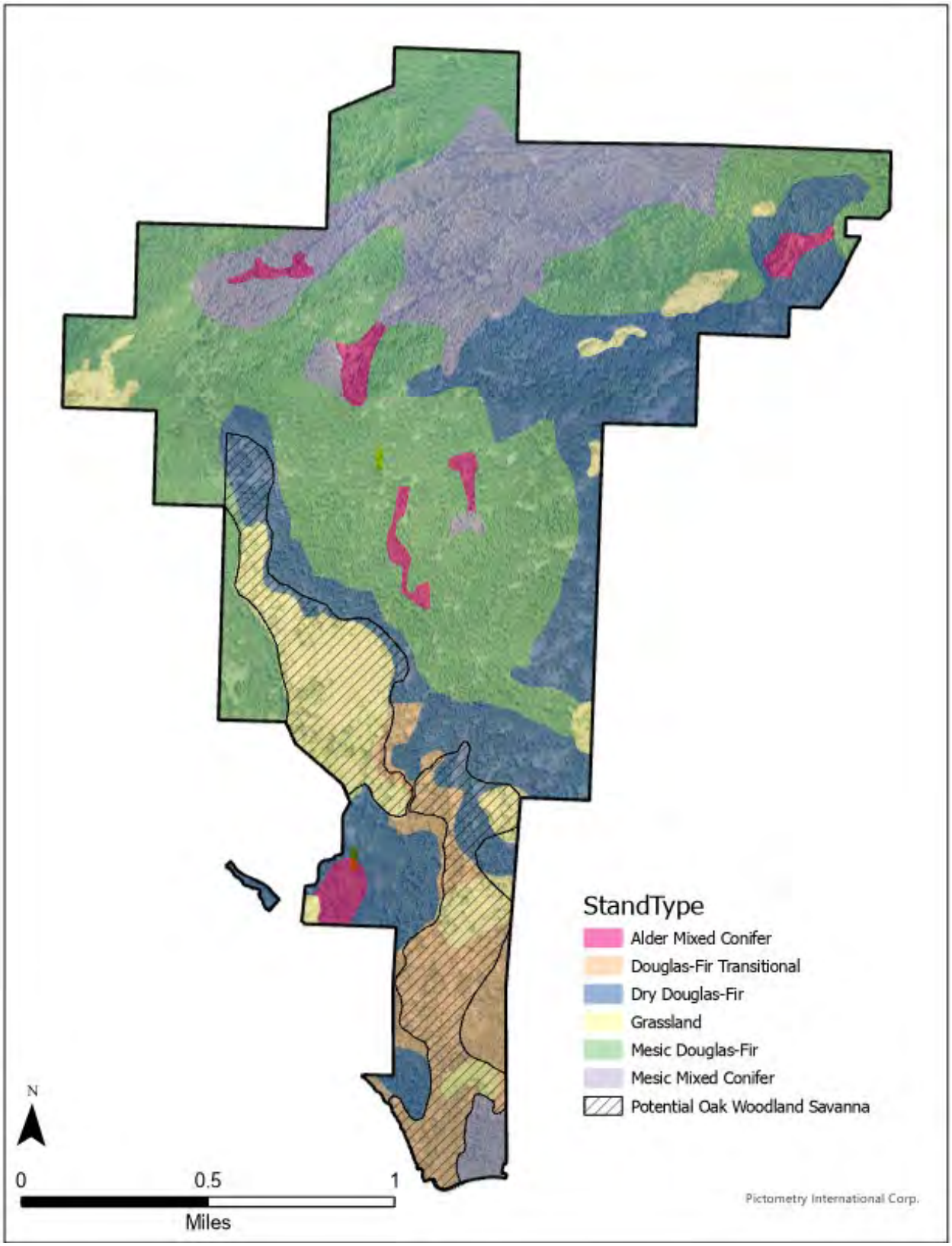


Figure 15 - Conceptual map for the location of a Garry oak woodland savanna habitat matrix. This could be extended into the southern portion of the Turtlehead preserve as well.

Recommended Management Timeline

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031-2035	2036-2040	2041-2050
Permanent plot monitoring												
Establish additional plots in stands 2 & 3	■											
Re-measure every 10 years									■		■	■
Roads and Trails												
Road maintenance, upgrades, and decommissioning												
• *Upgrade truck roads*	■											
• *Decommission U-1 to hiking trail*		■										
• *Upgrade U-2 and U-3 to truck road*	■											
Culvert inventory & monitoring	■				■					■	■	■
Fire safety												
Shaded fuel break installation												
• *Class I, Tier 1 - Initial installation*	■	■										
• *Class I, Tier 2 – Initial installation*		■	■									
• *Class II – Initial installation*			■	■								
• *Maintenance (4-6 years)*										■	■	■
Restoration Thinning Treatments												
Tier 1 Projects												
• *Thinning Rx II (Ground Based) – DDF-L-03 & DDF-L-07*	■	■										■
• *Thinning Rx III (Specialized Equipment) – DDF-M-05*	■	■									■	
• *Thinning Rx IV (Hand Crews) – DDF-H-03, DFT-L-01, DFT-M-01*	■	■									■	
Tier 2												
• *Phase 1 – Stands 1 (DDF) and 3 (DFT)*			■	■								■
• *Phase 2 – Stand 4 (MDF)*					■	■						■
• *Phase 3 – Stand 5 (MMC)*							■	■				■
Rx V – Targeted Canopy Release					■	■	■	■				■
Additional Monitoring and Restoration Work												
Grassland restoration			■	■								
Old-growth Douglas-fir census and mapping	■											
Update wetlands and stream classifications	■											

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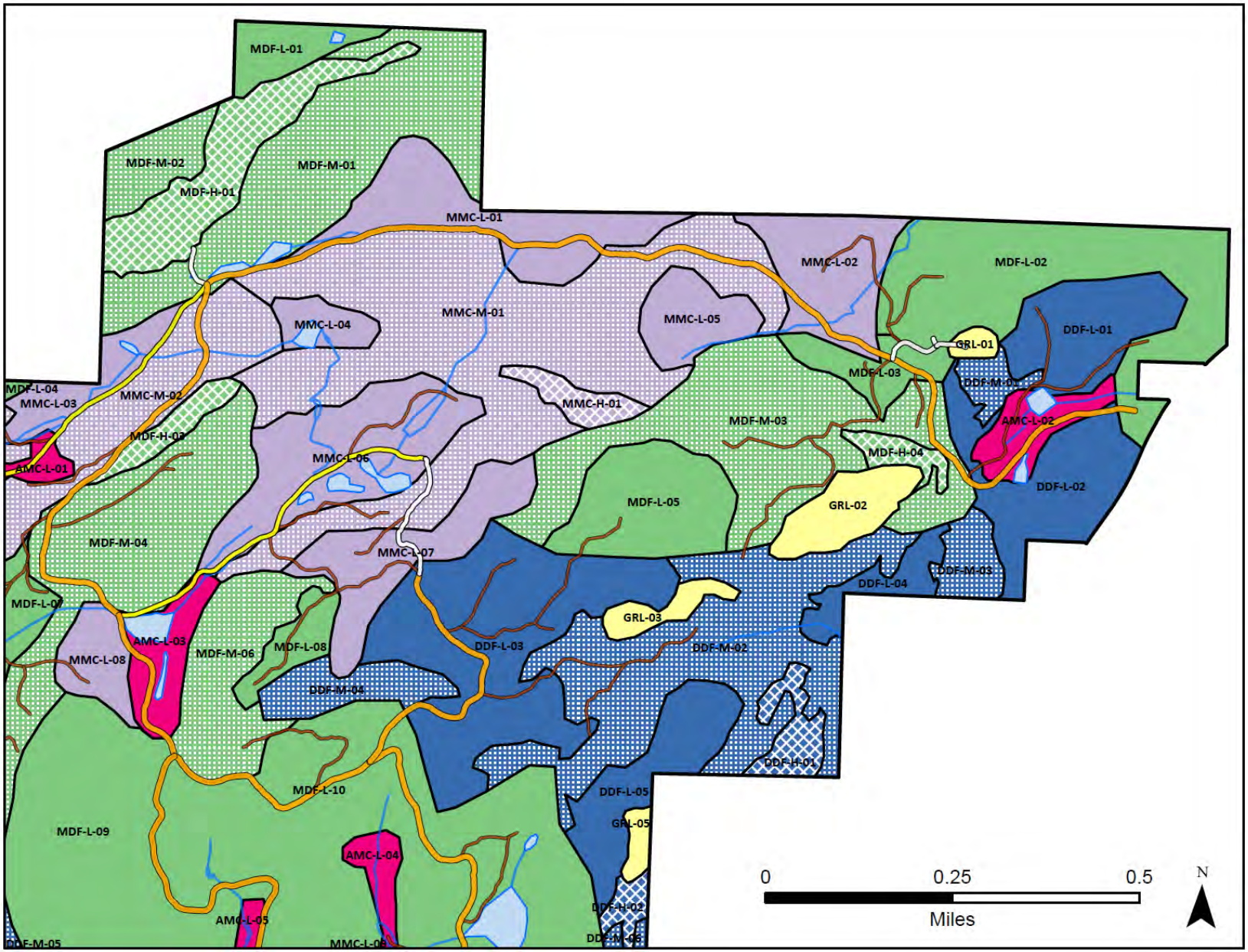
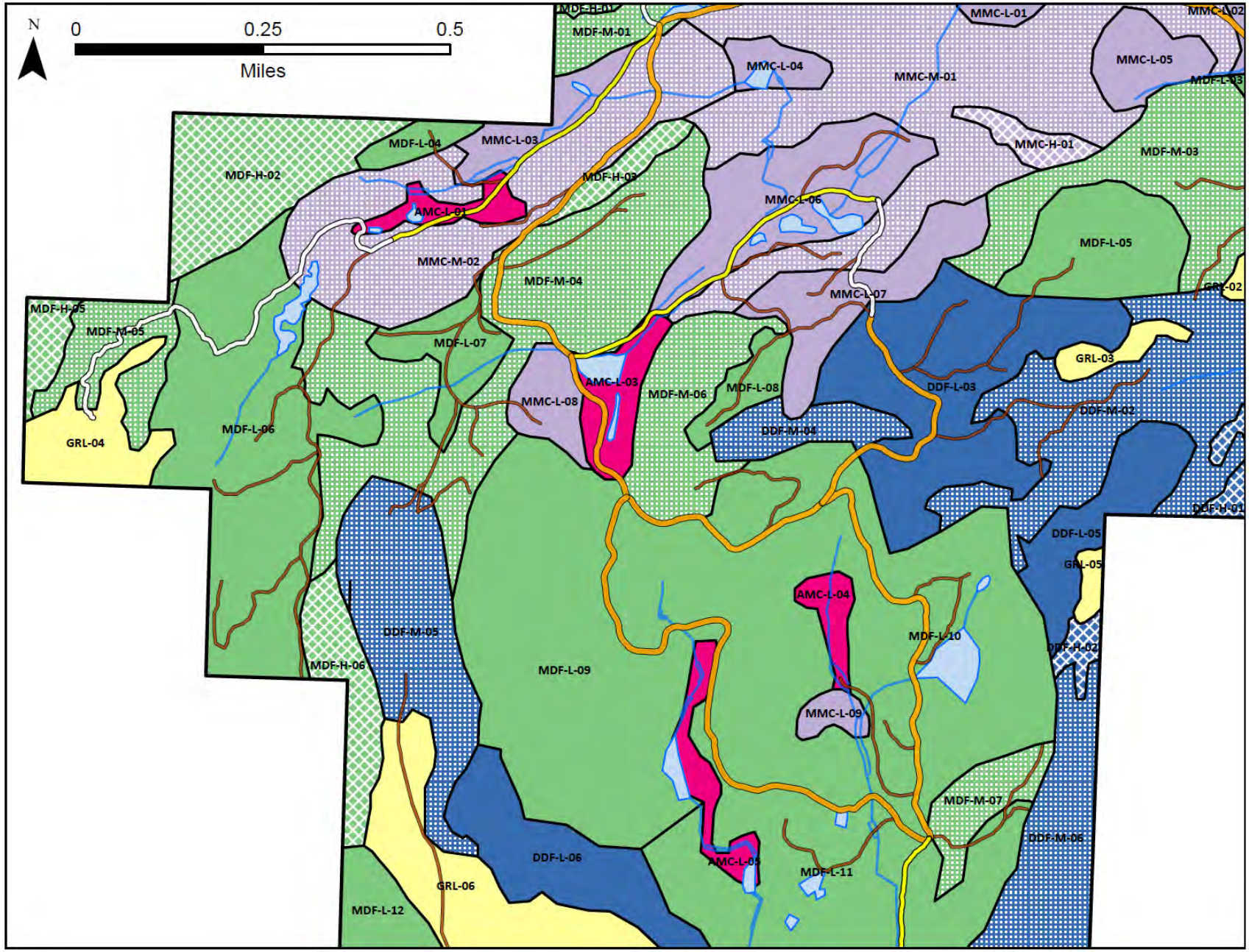
APPENDIX A: FOREST MANAGEMENT UNIT MAPS




N
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0.25
0.5
Miles
MDF-H-01
MDF-M-01
MMC-L-01
MMC-L-02
MMC-L-05
MDF-L-03
MMC-L-04
MMC-M-01
MMC-H-01
MDF-M-03
MDF-L-04
MMC-L-03
MDF-H-02
MDF-H-03
AMC-L-01
MMC-L-06
MDF-L-05
MMC-M-02
MDF-M-04
MMC-L-07
GRL-02
MDF-H-05
MDF-M-05
MDF-L-07
GRL-03
AMC-L-03
MDF-M-06
MDF-L-08
DDF-L-03
MMC-L-08
DDF-M-02
GRL-04
MDF-L-06
DDF-M-04
DDF-H-01
DDF-L-05
GRL-05
AMC-L-04
DDF-M-05
MDF-L-10
DDF-H-02
MDF-H-06
MDF-L-09
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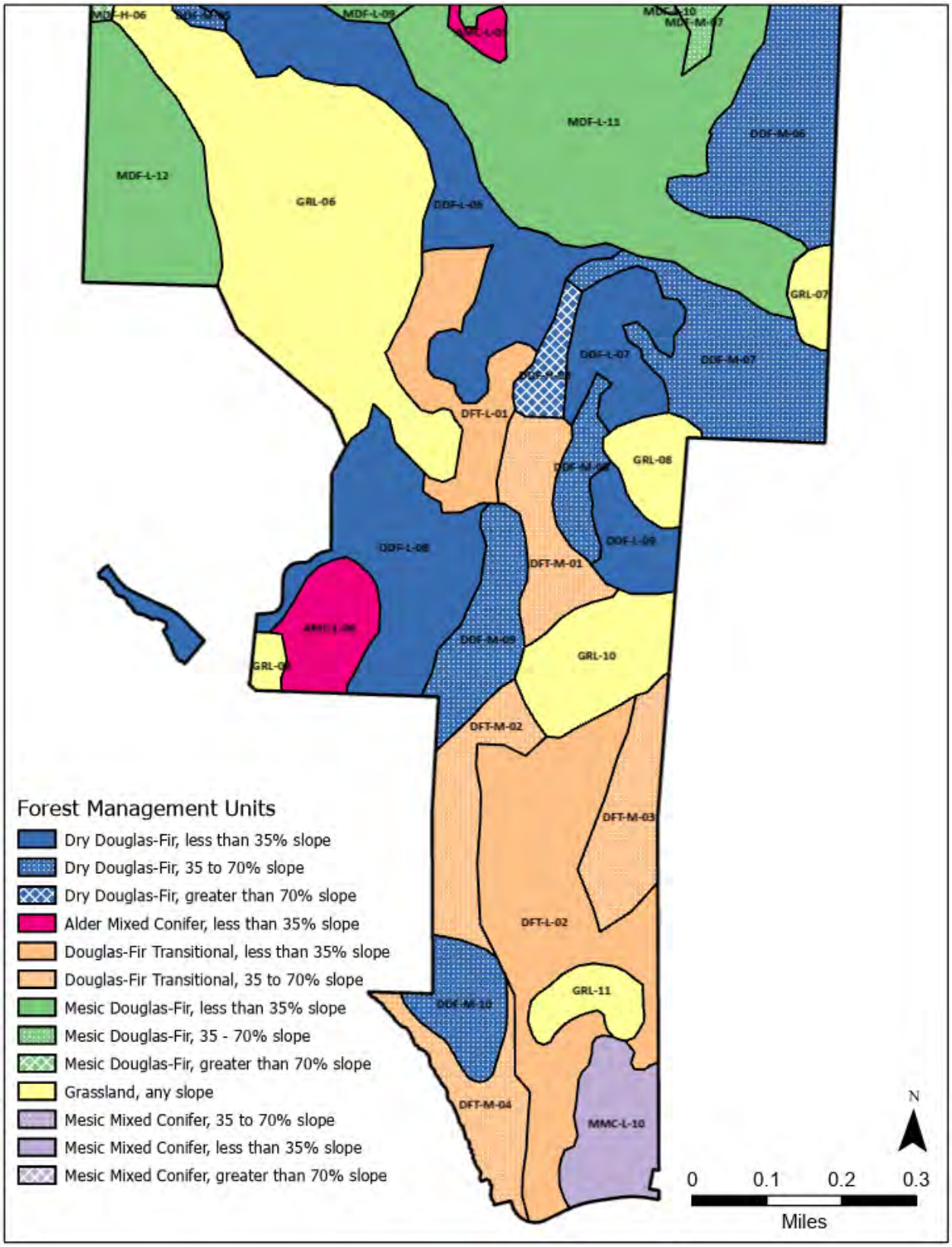
MDF-L-11
GRL-06
MDF-L-12


MDF-H-06
MDF-L-09
MDF-M-07
MDF-L-11
DDF-M-06
MDF-L-12
GRL-06
DDF-L-05
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DDF-L-07
DDF-M-07
DFT-L-01
GRL-08
DDF-L-08
DDF-L-09
DFT-M-01
DDF-M-05
GRL-10
DFT-M-02
DFT-M-03
DFT-L-02
GRL-11
DDF-M-10
DFT-M-04
MMC-L-10
Forest Management Units
Dry Douglas-Fir, less than 35% slope
Dry Douglas-Fir, 35 to 70% slope
Dry Douglas-Fir, greater than 70% slope
Alder Mixed Conifer, less than 35% slope
Douglas-Fir Transitional, less than 35% slope
Douglas-Fir Transitional, 35 to 70% slope
Mesic Douglas-Fir, less than 35% slope
Mesic Douglas-Fir, 35 - 70% slope
Mesic Douglas-Fir, greater than 70% slope
Grassland, any slope
Mesic Mixed Conifer, 35 to 70% slope
Mesic Mixed Conifer, less than 35% slope
Mesic Mixed Conifer, greater than 70% slope
N
0
0.1
0.2
0.3
Miles

APPENDIX B: PERMANENT PLOT MONITORING PROTOCOLS

There are 31 one-tenth-acre permanent forest monitoring plots throughout the Turtleback Mountain Preserve and Turtlehead Preserve. Their locations are provided in the *Turtleback_2020_Data-New_Plot_IDs_GPS_Coords* spreadsheet and as an ArcGIS shapefile with coordinates available in both *Latitude/Longitude* (WGS84) and *Northing/Easting* (NAD 1983 State Plane Washington North FIPS 4601 (US Feet). Plots should be monitored every 10 years, and new plots may be added depending on the need for additional data from each stand type.

The center of each plot is identified by a piece of rebar driven into the ground and covered by a short section of PVC pipe. A numbered tag corresponding to the *Plot Tag Number* in the dataset is affixed to the end of the PVC pipe with wire or zip-ties, and the pipe is either painted orange or wrapped with orange flagging. At each plot, data is collected and recorded in four categories: general plot information, overstory measurements, subplot measurements, and coarse woody debris.

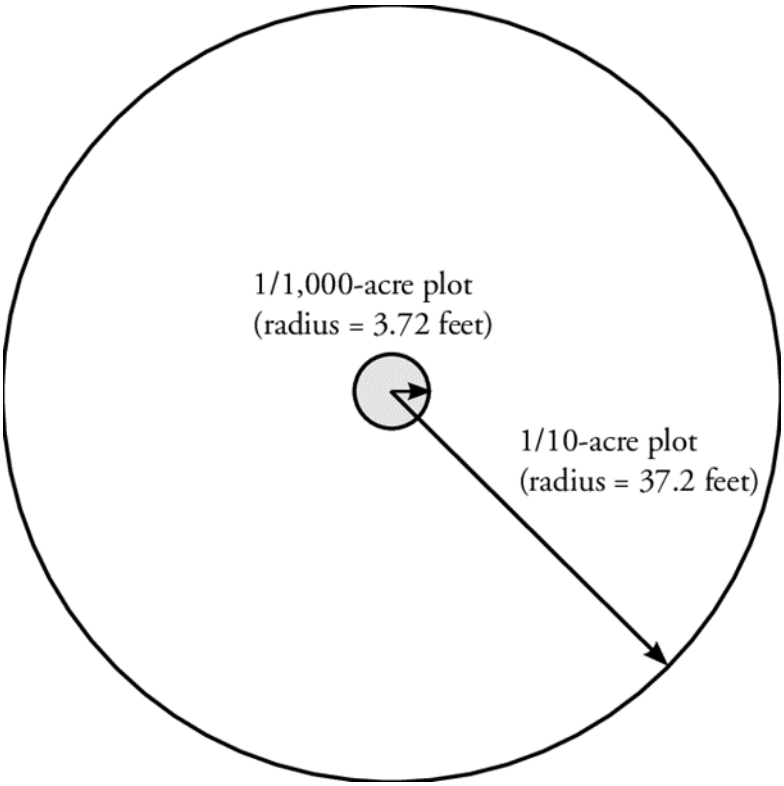

Figure 16 - Plot diagram showing the 1/10-acre plot and 1/1000-acre subplot

General plot information

At each plot the following information should be confirmed (existing plots) or measured (new plots), and recorded:

- Date, names of observers, and notes on the condition of the plot, plot marker, and tags. Missing markers or tags will be replaced and new plot tag numbers noted on the data sheet.
- Geographic location, measured with a handheld Garmin GPS
- Elevation, using the GPS elevation
- Slope, measured with the clinometer on a Silva Ranger compass
- Aspect, measured with a compass, assuming 15.9 degrees east declination as of 2020
- Profile – concave, convex, planar
- Photos – four photos looking toward each cardinal direction (north, south, east, west) holding the camera level at 4.5'.

Overstory plot

All trees from initial /previous measurement should be relocated and accounted for. Note any missing trees or missing tags. All new trees in plot, alive or dead, with a diameter at breast height of 2.0" or greater are to be tagged and included in the plot. Install a tag on any new trees using a 3" aluminum roofing nail at breast height. Tag orientation on the tree is towards the plot center, or as close as possible if steep topography prevents this tag orientation.

Tag numbering: If an observer stands at plot center facing true north (declined 15.9 degrees east as of 2020), the lowest-numbered tree will typically be the first tree to the right of the line running north from the plot center.

When establishing a new plot, the horizontal distance of trees from plot center should be measured with a laser hypsometer/rangefinder and all trees within 37.2' from plot center (measured to the center of the bole) should be included in the plot. Trees should be tagged sequentially moving clockwise from the line running north from plot center, according to the tagging guidelines above.

Variables recorded in field for each individual overstory tree (live or dead) are as follow:

1. Tag number
2. Species
3. Diameter at breast height (DBH). Breast height is defined as 4.5 feet above the contour line running tangent on uphill side of tree.
    - Variable measured with standard forestry tape
    - Unit: inches and tenths of inches
    - Population measured: all trees, live or dead, in all plots, above 2" diameter at breast height
    - Independent variable for: volume, height, basal area

4. Top diameter (for snags OR live trees with obvious top breakage)
    - Defined as the diameter of the snag up to the point where top obviously deviates from a circular cross-section
    - Best visual estimate
    - Unit: Inches (integer)
    - Population measured: all snags
5. Height
    - Height is the vertical distance from the elevation of the contour line running through center of tree to the top needle, bud, or branch of the tree, or top splinter or block of a snag
    - Variable measured with laser hypsometer/rangefinder
    - Unit: feet (in integer units)
    - Population measured: all snags, subsample of live trees representative of the average height for the plot
6. Status
    - Definition: whether tree is living (shows green foliage) or dead: no green foliage, signs of decay present, and what decay class tree is in.
    - Unit (range of possible values)
        - Live
            - Tree is alive
            - Determinant characteristics: presence of living (green) foliage
            - Datasheet code = “L”
        - Decay Class One
            - Tree is dead, and in decay class one
            - Determinant characteristics: lack of living (green) foliage. Bark and wood still sound. Both large and fine branches still present
            - Datasheet code = “DC 1” or “1”
        - Decay Class Two
            - Tree is dead, and in decay class two
            - Determinant characteristics: lack of living (green) foliage. Bark is beginning to loosen, but sap- and heartwood still sound. Large branches present, but most fine branches gone
            - Datasheet code = “DC 2” or “2”
        - Decay Class Three
            - Tree is dead, and in decay class three
            - Determinant characteristics: lack of living (green) foliage. Bark mostly or completely missing, and either heartwood or sapwood relatively

soft (but cannot be readily disintegrated with impact of a foot). Both large and fine branches largely gone
        - Datasheet code = “DC 3” or “3”
    - Decay Class Four
        - Tree is dead, and in decay class four
        - Determinant characteristics: lack of living (green) foliage. Bark totally missing. Both heartwood and sapwood soft and can be readily disintegrated with a kick. Some remnant large branches remaining. Sides of snag still able to resist pull of gravity
        - Datasheet code = “DC 4” or “4”
    - Decay Class Five
        - Tree is dead, and in decay class five
        - Determinant characteristics: lack of living (green) foliage. Bark totally missing. Both heartwood and sapwood soft and can be readily disintegrated with a kick. Large branches not remaining. Sides of snag mostly unable to resist pull of gravity; snag is typically no more than 2.5 meters in height
        - Datasheet code = “DC 5” or “5”
7. Notes. The “Notes” column is used to describe any observations about the tree that are potentially relevant to condition, causes of mortality, decomposing organisms (if dead), structure (such as split trunk at a certain height), etc.

Subplot

Within a 1/1000-acre (3.72’ radius) subplot at the center of each plot record the following:

- Tally of tree saplings (<2” DBH and taller than 4.5’) and seedlings (<2” DBH and shorter than 4.5’) by species
- Species and percent cover of understory shrubs and major herbaceous species

Coarse Woody Debris

The line-intercept method is to be used, as described below:

Van Wagner (1968) proposed the line intersect method as an efficient method for sampling woody forest residues. Parminter (1998) reviewed down woody debris sampling and concluded that one triangle with 30 m (100’) sides of line-intersect transect per ha (2.47 acres) would result in sufficient sampling for most forest types. Arranging transects in a triangle ensures that anisotropy in tree-fall direction (due to predominant wind directions, overstory structure, or topography) will not bias volume estimates. We centered three 100’ transects as an equilateral

triangle on most of the overstory sampling points (Figure 2). Woody debris volumes are typically more variable than overstory volumes.

Along each transect, each piece of woody debris with one axis greater than 4” was measured. Species (if possible), horizontal diameter, vertical diameter, and decay class was recorded for each intersected piece (Harmon and Sexton 1996). Horizontal and vertical diameter was measured in inches with a forestry caliper (Haglof, Inc., Madison, Mississippi). Decay class definitions followed Harmon and Sexton (1996) and Cline et al. (1980), with decay class 1 being least decayed, and 5 being most decayed.

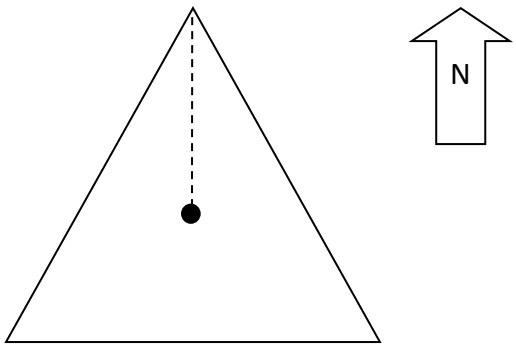

Figure 17 - Coarse woody debris line-intersect transect arrangement (triangle) around overstory plot point (black dot). Distance from center to vertex (dashed line) is 43.3’. Each side of the triangle is 100’ long. Azimuth progression (counter-clockwise) is 210°, 90°, and 330° (true azimuths).

1. Species
    - Defined according to the species outlined in the overstory section.
    - Population measured: all woody debris with one diameter dimension larger than 4”.
2. Decay class
    - Defined as the categorical description of level of decay, as described by Harmon and Sexton (1996).
        - Decay class 1: bark still intact, fine branches present.
        - Decay class 2: bark sloughing, wood still firm, most large branches still present.
        - Decay class 3: bark largely absent, wood may be somewhat firm (able to “bridge”), most large branches absent.
        - Decay class 4: bark absent, wood soft but able to maintain hemispherical profile or slight overhang.
        - Decay class 5: usually very soft and moss-covered; almost indistinct from forest floor.
    - Unit: categorical value, 1-5.
    - Population measured: all woody debris with one diameter dimension larger than 4”.

3. Horizontal diameter
    - Data sheet column header: DIA
    - Horizontal diameter of the woody debris as measured with forestry calipers.
    - Unit: inches.
    - Population measured: all woody debris with one diameter dimension larger than 4”.
4. Vertical diameter
    - Data sheet column header: DIA2
    - Vertical diameter of the woody debris as measured with forestry calipers.
    - Unit: inches.
    - Population measured: all woody debris in decay classes 4-5, or any piece of woody debris that is clearly asymmetrical.

Methodology References

Cline, S. P., A. B. Berg, and H. M. Wight. 1980. Snag characteristics and dynamics in Douglas-fir forests, Western Oregon. Journal of Wildlife Management 44:773-786.

Harmon, M. E. and J. Sexton. 1996. Guidelines for measurements of woody detritus in forest ecosystems. U.S. LTER Network Office: University of Washington, Seattle, WA, USA.

Parminter, J. 1998. Coarse woody debris sampling intensity considerations. Ministry of Forests, Research Branch, Victoria, British Columbia. Online at: http://www.for.gov.bc.ca/hre/deadwood/DTmes5.htm

van Wagner, C. E. 1968. The line intersect method in forest fuel sampling. Forest Science 14:20-26.

APPENDIX C: MANAGEMENT COST ESTIMATES

Road Improvements

No cost information for road improvements is available at this time. Budgeting for the recommended work would best be informed through consulting with a road engineer or local expert.

Shaded Fuel Breaks

Shaded fuel break installation cost estimates are based on costs per mile of treatment for a single side of road/trail. The tables below list ranges of typical installation costs by fuel break width (20' vs. 50' vs. 75'). Our GIS analysis suggests the need for 8.2 miles (single side) of 50' width shaded fuel breaks, 5.3 miles of 75' shaded fuel breaks, and 3.5 miles of 20' shaded fuel breaks if all suggested priority roads are treated. Each category of treatment has an associated range—and the range in costs for roadside fuel breaks are fairly wide. This range is indicative of the variable nature of tree density, fuel arrangement, slope and other aspects. These costs are based on actual fuel reduction contracts on Orcas, San Juan, and Waldron Island over the last 10 years. It is recommended that Land Band staff use these ranges for budgeting purposes but also pursue an open bidding process for any planned work.

Table 19 - Shaded fuel break cost estimates with range in costs per mile for single side of roads.

CLASS I SHADED FUEL BREAKS				
	Cost per mile/single side 50' width		**Cost per mile/single side 75' width**	
	Low Range	*High Range*	*Low Range*	*High Range*
Roads	$5,443	$26,364	$10,887	$32,727
CLASS II SHADED FUEL BREAKS				
	Cost per mile/single side 20' width			
	Low Range	*High Range*		
Trails	$3,636	$6,787		

Ecological Thinning Using Ground Based Equipment

For projecting costs of the restoration thinning using ground-based equipment, we used costs per acre and incorporated potential timber value. Overall treatment size has a large impact on these costs and contracts involving less than 60 acres were considered too small to accurately estimate. Contracts involving 120 or more acres will likely drive some of the costs down. Equipment move-in/set-up costs were not estimated but these typically range from $2,000-$5,000 per contract.

Timber value represents a delivered mill price for an average load of mixed species, mixed grade. The value we used is $620/*mbf* minus a fixed per load trucking cost of $925. Average load volume per truck is 3 *mbf*.

Cutting and processing cost estimates for ground-based systems were based on fixed costs of $380/*mbf* with a 25% increase for the upper end of the range.

Slash treatment costs using low-tech and currently available Bio-char processing methods (i.e., flame cap mobile kilns, large flame cap transportable kilns, and conservation burns) were estimated using a fixed $1,400-2,100/ acre for DDF and DDT and a $1,000-1,500/ acre for MDF and MMC stands.

Table 20 - First stand entry restoration thinning costs and potential timber value. Costs and timber values are all per acre

Stand Type	Volume Removed *mbf*/acre	Layout, tree marking	Cutting/ Processing	Slash Rx (Bio-char)	Timber Value
DDF	1.5 *mbf*	$65	$570-710	$1,400-2,100	$467
AMC	-	-	-	-	-
DFT	1 *mbf*	$80	$380-470	$1,400-2,100	$311
MDF	5.5 *mbf*	$65	$2,090-2,610	$1,000-1,500	$1,685
MMC	3 *mbf*	$65	$1,140-1,420	$1,000-1,500	$935

Table 21 - Second stand entry restoration thinning costs and potential timber value. Costs and timber values are all per acre.

Stand Type	Volume Removed *mbf*/acre	Layout, tree marking	Cutting/ Processing	Slash Rx (Bio-char)	Timber Value
DDF	6.5 *mbf*	$75	$2,470-3,080	$1,400-2,100	$2,032
AMC	-	-	-	-	-
DFT	4 *mbf*	$90	$1,520-1,900	$1,400-2,100	$1,247
MDF	7.5 *mbf*	$75	$2,850-3,560	$1,000-1,500	$2,338
MMC	5.5 *mbf*	$75	$2,090-2,610	$1,000-1,500	$1,685

Ecological Thinning Using Specialized Equipment

Due to the complexity of these systems, no cost estimating was conducted for these treatments. However, it can reasonably be assumed that the overall costs may be quite similar to ground-based systems despite the steeper terrain. Cable suspension systems, once set-up can be fairly productive at moving biomass. These systems can also work well for whole-tree yarding which provides opportunities for scaled up Bio-char production systems that may reduce costs and even provide some additional revenue to offset overall treatment costs.

Ecological Thinning Using Hand Crews

For projecting costs of the restoration thinning using hand crews, we used costs per acre for both cutting and slash processing. There are no opportunities for timber offset values. Like the ground-based systems, overall treatment size has a large impact on these costs and contracts involving less than 20 acres were considered too small to accurately estimate.

Cutting and processing cost estimates for hand crews were based on fixed costs of $1,800/acre with a 25% increase for the upper end of the range.

Slash treatment costs were estimated for conservation burns only due to the steeper slopes and remote locations. These costs were fixed at $1,800-2,700/ acre for DDF and DDT and a $1,600-2,400/ acre for MDF and MMC stands.

Table 22 – First and second stand entry restoration thinning costs for hand crews. Costs are all per acre.

Stand Type	Volume Removed *mbf/*acre	Layout, tree marking	Cutting/ Processing	Slash Rx (Bio-char)
DDF	-	$65	$1,800-2,250	$1,800-2,700
AMC	-	-	-	-
DFT	-	$80	$1,800-2,250	$1,800-2,700
MDF	-	$65	$1,800-2,250	$1,600-2,400
MMC	-	$65	$1,800-2,250	$1,600-2,400