

SHADOW Bog

Conservation Activity Plan



Fall 2016

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Forest name:	SHADOW Forest	
# of acres plan covers:	22	
County and state:	King, WA	
USDA Farm & Tract #:	Farm # 1144 Tract # 1380	
Date plan prepared:		
Plan Preparers:		
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This plan meets the requirements of the Washington Specification Guide for the NRCS Conservation Activity Plan.

Natural Resource Conservation Service

Date

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A. Landowner Objectives

The Save Habitat and Diversity of Wetlands (SHADOW) non-profit owns and manages 100 acres of forest, forested wetland, wetland, and bog habitat, and freshwater shoreline with conservation objectives. SHADOW acquires new parcels with the goal of improving wetland habitat, wildlife habitat, and ecological function, particularly along the high conservation sphagnum bog along Shadow Lake. The most recent acquisition totals 22 acres including upland and wetland forests. The acquisition of this property offers the rare opportunity to preserve bog habitat and enhance surrounding forest habitat towards old growth conditions within a key geographic landscape.

SHADOW's goals for their lands include:

- Protect sphagnum bog habitat;
- Maintain and enhance Shadow Lake shoreline habitat, wildlife habitat, and forest health;
- Restore forest habitat to old-growth species composition, structure and age classes;
- Provide infrastructure for education and outreach;
- Provide public access on defined trails

The property will be used as protected forest for fish and wildlife habitat, education, and recreational access. There is no intention of development. Future habitat enhancement projects may include restoration-oriented thinning, tree planting and strategic tree felling or girdling. Revenue from forest management is not a management objective; however, any opportunity to offset management cost or generate revenue to re-invest in restoration work is welcome. Forest management activities must be founded in strong ecological rationale promoting the goal of old-growth forest habitat structure and function.

The desired future condition of SHADOW forest habitat is to conserve and promote diverse species, structure, and age classes on a trajectory towards old-growth conifer-dominated conditions, generally following the Franklin et al. (2002) article on western Cascade conifer forest stand development. This includes management that mimics natural disturbance patterns, enhancing growth of large-trees, increasing tree and shrub diversity, and spatial heterogeneity. Key outcomes include resilience to climate change through tree species diversity and forest structure that promotes water retention and drought tolerance. Carbon storage through promoting long-lived conifers is another key outcome. Specific forest management objects to accomplish these goals are described in Section F. Resource Category IV: Forest Inventory.

SHADOW has a unique educational component to its mission, including buildings and staff dedicated to school groups and community outreach. Respectful visitor participation enhances the community's appreciation of the unique bog and forest habitats.

The management recommendations in this plan are designed to achieve these landowner goals over short- and long-term timeframes.

B. Introductory Overview of the Property

1. Landowner Information

SHADOW owns several contiguous parcels totaling approximately 100 acres, and continually seek to acquire more land. SHADOW leads school and community groups on educational tours through their property, teaching them about the critical and unique bog habitat and surrounding forest. The property is located about 2 miles northwest of Maple Valley and 8 miles southwest of Renton.

2. General Description

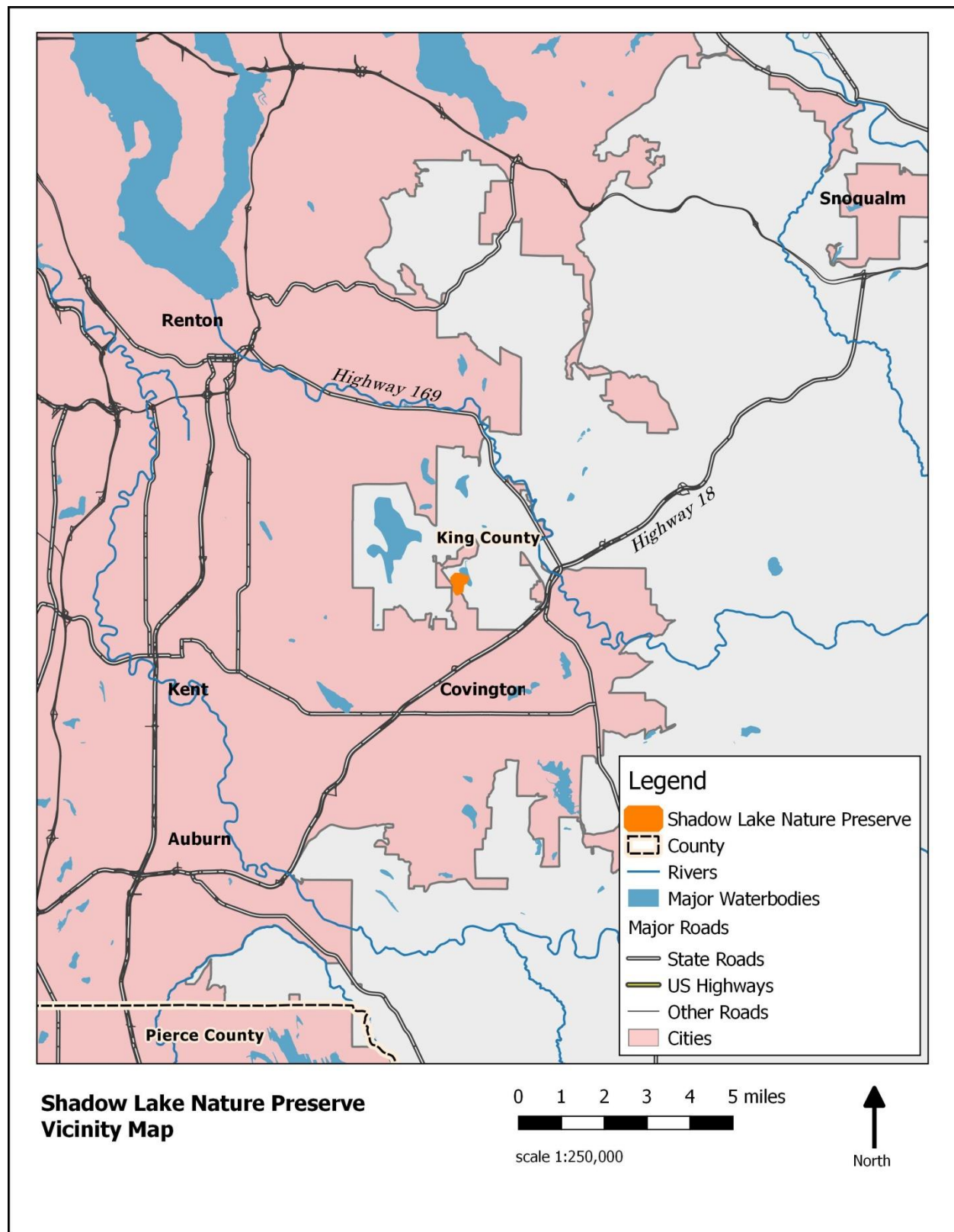
The SHADOW property is located at the urban-rural interface with the Puget Sound metro area. Wetland draining to Shadow Lake define the property. Elevation of the property ranges from 550 to 600 feet above sea level. The central and eastern portions of the forest were clearcut logged around 1990 and have regenerated in mostly red alder with cottonwood and bigleaf maple. The northern side and southern spur of the property contain some larger second-growth conifers that regenerated following the initial clearcuts in the mid-1900s.

Parcel numbers are 072206-9015 and 072206-9189, located in the south half of Township 22, Range 6, Section 7, with a small portion located in the northwest ¼ of the northwest ¼ of Township 22, Range 6, Section 18 of King County.

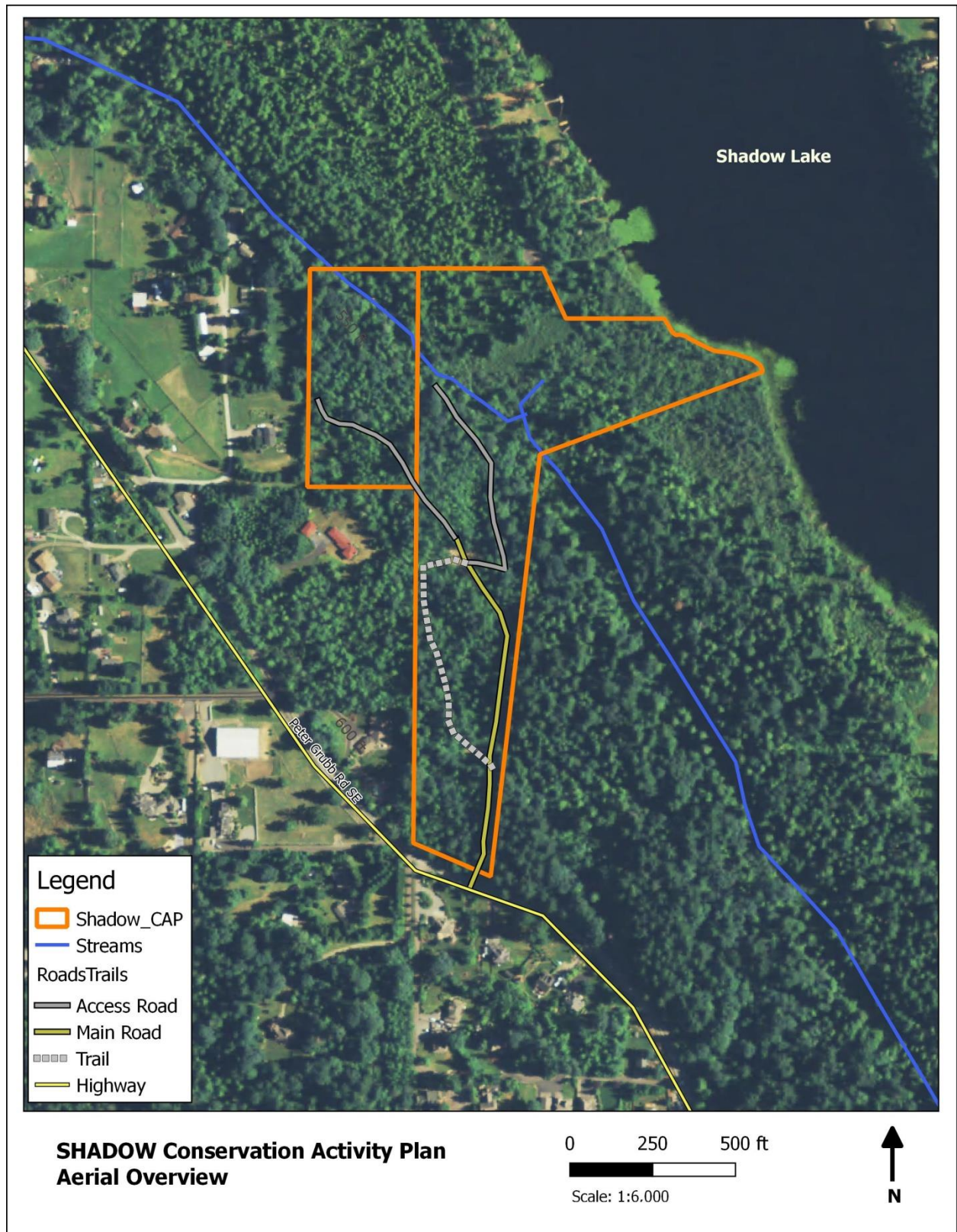
Adjacent Properties

The property is bordered by private land to the west and south. SHADOW purchased and then transferred the land east of these parcels to King County. SHADOW currently owns lakefront and lake view lots to the north. Private lots are zoned single family residential. Forest land on adjacent properties is a mix of non-intensively managed as well as intensively managed (i.e., clearcuts) based on aerial photo interpretation. The SHADOW forest occurs as part of a mosaic of land uses shifting from development to rural land uses.

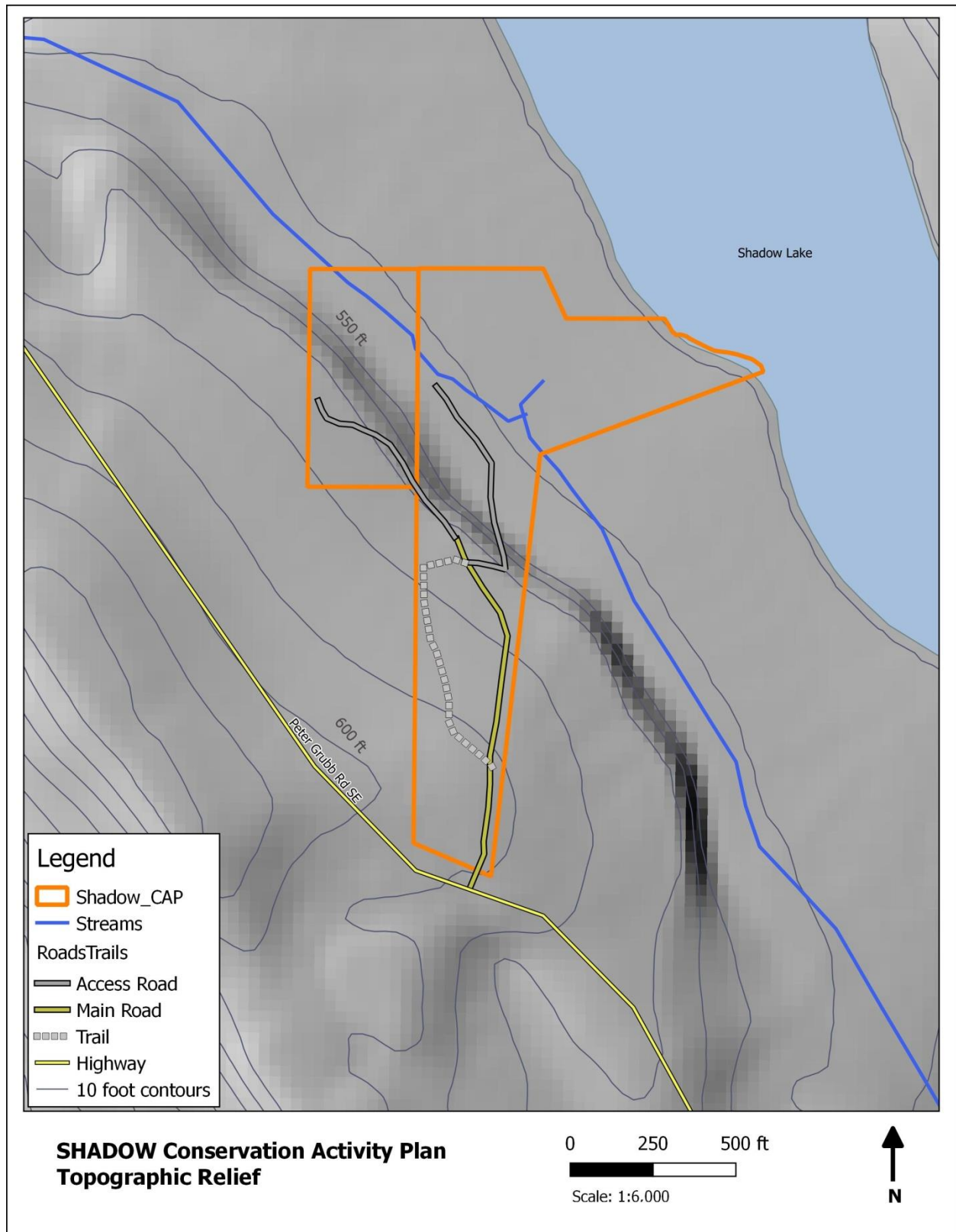
Map 1: Vicinity map of the SHADOW Forest.



Map 2: Detail aerial photo of SHADOW Forest



Map 3: Topographic map with hillshade background of SHADOW Forest



Region Overview and Landscape Context

The SHADOW property is located in south central King County, about 30 miles from Puget Sound to the west. The property is adjacent to Shadow Lake, which drains to the Green River and ultimately Elliot Bay of Puget Sound in Seattle.

The region is composed of glacial till soils formed by glacial activity of the Puget Lobe of the Cordilleran Ice Sheet in the last ice age about 10,000 years ago. The property lies at the transition between the Puget lowlands and the Cascade Mountains. The Cascade Mountains strongly influence rainfall; the property receives substantially higher rainfall than communities to the west that are lower in elevation.

Forests in the region are mixed conifer forest in the western hemlock zone of the North Cascades province (Franklin and Dyrness 1988). Most forests in the area were clearcut or high-grade logged in the 1900s; most forests on the landscape have regenerated from this unnatural disturbance to forest compositions that do not resemble the original forests. Douglas-fir (*Pseudotsuga menziesii*) dominates the mixed conifer forest; though bigleaf maple (*Acer macrofolium*), western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), and red alder (*Alnus rubra*) are also common.

King County is an economic driver of the region, including Seattle and adjacent cities. The region is rapidly developing, though large forest expanses are secured under long-term Federal, State, County, and industrial forestry ownership. The nearby economy is diverse and robust, including global industrial, technological, and natural resource companies. Smaller town centers, agricultural land uses, and forest are distributed throughout the region. Private forest land is a mixture of industrial and non-industrial owners. Some of the forested areas are held for residential and recreational sites and for investment purposes. The soils of the county have a high potential for wood production. The management of the forest land is varied, ranging from intensive timber production to no active management at all. Logs are sold for processing into a variety of wood products, including dimension lumber, furniture, pulp, plywood, utility poles, piling, shakes and shingles, and fence posts. Mills and markets for conifer and hardwood logs exist within a reasonable haul distance in King, Pierce, and Snohomish counties.

Climate

The climate of this area is temperate maritime, with cool rainy winters and warm dry summers. Annual average rainfall is 36.4 inches, with negligible or zero snow, measured at Renton International Airport from 1981-2010 (NRCS Climatic Data 2016). In the dry summer months, several weeks may pass without precipitation. In January the average high and low temperatures are 48°F and 37°F, respectively. The July average high and low temperatures are 77°F and 57°F, respectively. In most winters, one or two storms bring strong and sometimes damaging winds in excess of 60 miles per hour, and in some years the accompanying heavy rains cause severe flooding and mass wasting events (landslides).

Climate change forecasts for the region indicate warmer, wetter conditions resulting most notably in conversion of winter precipitation from snow to rain at higher elevations.

3. Documentation of Existing Practices

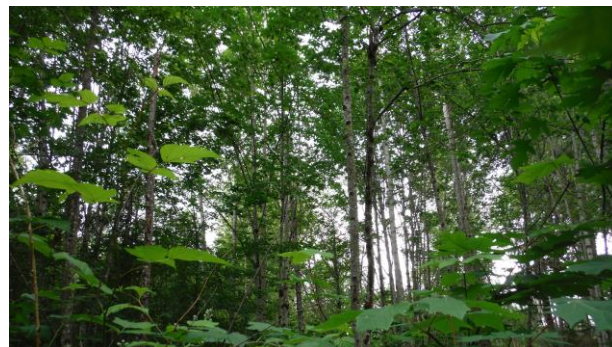
SHADOW consists of two main upland forest ecotypes: a young red alder forest type and a more mature mixed conifer-hardwood forest type. Much of the property is forested wetland including western hemlock-sphagnum bog forests, with scrub/shrub habitat also present. Since SHADOW purchased the land, management includes blackberry control and low-density under-planting near roads and trails in the alder forest. Plantings have been occasionally successful including some Sitka spruce and western redcedar that have emerged beyond the competing shrubs. No logging has taken place since SHADOW purchased the land.

Table 1: Acreage by vegetation type

Forest Type	Acres
Hardwood forest	8
Mixed Conifer	2
Lowland hardwood and riparian forest	6
Forested and open bog	2.5
Shrub/scrub wetland	1.5
Grass, roads, and plant nursery	2
Total	22

4. Past Harvest History

The SHADOW forest is a third-growth forest. Management has focused on the upland area. The property was initially logged in the early- to mid-1900s. No remnant trees remain to verify timing of the initial harvest. The forest most likely naturally regenerated. A previous landowner clearcut harvested the upland forest area around the year 2000, with the exception of a 2-acre patch on the south end of the property. The previous owner also selectively cut high-value logs from the lowland forest adjacent to the access road. After that harvest, red alder rapidly established as the dominant species; it is unclear if the forest was initially replanted to conifers and failed, or if the unit was never replanted after harvest.



Alder forest type.

5. Identification of Resource Concerns

Resource concerns focus on low productivity and density-dependant mortality due to high stand density and broken tops from wind or ice damage, and homogenous species composition and forest structure. Invasive plant species are present and are problematic near roads and trails and in the alder stand. The following resource concerns were identified during field visits as existing conditions that do not meet the landowner's objectives.

Resource Concerns

- Degraded plant condition – Undesirable plant productivity and health
- Degraded plant condition – Inadequate structure and composition
- Degraded plant condition – Excessive plant pest pressure

Each resource concern is described in greater detail in the Forest Inventory section of this Conservation Activity Plan.

C. Resource Category I: Forest Health

Resource Conditions

Three main forest health issues affect the SHADOW property.

1. **Low-vigor tree growth** (Resource Concern: Undesirable plant productivity and health) results in slow growth and density-dependent mortality, further compromised by many trees with broken tops from wind or ice damage (more thoroughly discussed in Section F below).
2. **Severely limited regeneration** (Resource Concern: Inadequate structure and composition) throughout the unit. The combination of full-canopy enclosure and a dense layer of shrubs are currently preventing desirable tree species from establishing (more thoroughly discussed in Section F below).
3. **Invasive plants** (Resource Concern: Excessive plant pest pressure) such as English holly (*Ilex aquafolium*) and Himalayan blackberry (*Rubus discolor*) are found throughout the property. These invasive plants can outcompete native plant communities including tree seedlings, leaving the forest below its timber carrying capacity and severely reducing wildlife and habitat value.



English Holly.

Additional forest health risks include wind, disease, insects, and fire. These are not currently present in the property but are issues for which forest owners should monitor.

Wind, disease, and insect disturbance

Disturbances from insects, diseases, drought, and damage from wind and ice affect all forests. The property has signs that some of these disturbances have occurred in the past, such as blown down trees from windstorms. However, the current conditions do not warrant active forest management to prevent or mitigate risk of these events. In fact, some small-scale disturbances can help improve forest heterogeneity by creating patches and small gaps, thereby improving wildlife habitat.

Red alder has a relatively short life span, beginning to lose branches and tops and incurring heart rot around age 60 depending on site conditions (Deal and Harrington 2006). Harvesting red alder before it degrades in quality will capture economic value and will allow improvements to ecological health through planting a more diverse and long-lived forest.

Although no root rot pockets were observed during the site visit, root rot can be a productivity concern and should be monitored to prevent significant timber loss. Root rot is caused by pathogenic fungi, typically either (*Phellinus weirii*) or Armillaria (*Armillaria* spp.) and can greatly affect Douglas-fir and western hemlock. Both types can aggressively transmit infection through root-to-root contact and are capable of a rate of expansion of about 1 foot per year. They also survive in a latent state in old stumps and transition to their aggressive stage once they come into contact with live roots. The rate of infection is often correlated with other forms of disturbance (including insect mortality and damage from heavy equipment as well as drought). One year of drought is unlikely to greatly impact root rot infection rates, however successive years of drought could significantly stress trees and predispose them to infection.

Wildfire

The risk of large-scale forest fire disturbance is low on the property. For example, the historical fire return interval for western hemlock-Douglas-fir forests is generally 100 years or more in this region (Agee 1993). However, given the close proximity of the property to the public county road and several nearby residences, there is an increased risk of introduced fire from human-caused ignition pathways. The risk of these fires is higher during the dry summer months. Wildfire fighter access to property is an important factor in reducing the risk of loss due to fire. Roads should be maintained for high-clearance 4-wheel drive vehicles at a minimum. Road access on the property for fire control is currently limited.

Forest Health Management Recommendations

Plant Productivity and Health; Forest Structure and Composition

Forest thinning in response to high stand density and limited regeneration concerns are detailed below in the management recommendations section F, Resource Category IV: Forest Inventory. These recommendations aim to improve not only individual tree health but also the ecological value of the forest.

Excessive Plant Pest Pressure

Himalayan blackberry is prevalent on the property. Treatment includes mechanical and chemical removal. Long-term, establishing a tree canopy to shade out the plant will effectively reduce its viability.

For spot treatment of Himalayan blackberry, herbicide treatment in the late summer is effective, using Garlon or Crossbow herbicides. For exceptionally dense areas, a two-stage treatment is effective. This requires mechanically cutting back the invasives in the winter, and then applying herbicide in the spring after leaf out but before fruiting. Cutting is not fatal to the blackberry, but it is a set back to their development in the spring. Since the shrubs are smaller, it takes less herbicide to treat them in the spring. The shrubs are vulnerable because they have to spend so much energy regenerating their growth in addition to producing flowers, so the targeted herbicide is effective. This also results in less impact to the native shrubs compared to more widespread application in the fall.

English holly is also present at low levels. It is extremely shade tolerant and its abundance will likely steadily increase, efforts to eradicate it should be a priority. Also, care should be taken when conducting any forest management treatments on the property. Holly is difficult to remove by cutting alone because it re-sprouts quickly. A more effective method of control is to cut the stem of the tree and apply herbicide to the stump. If herbicide use is undesirable, cutting should be done but will require ongoing maintenance of new growth. Small holly seedlings should be pulled manually when found.

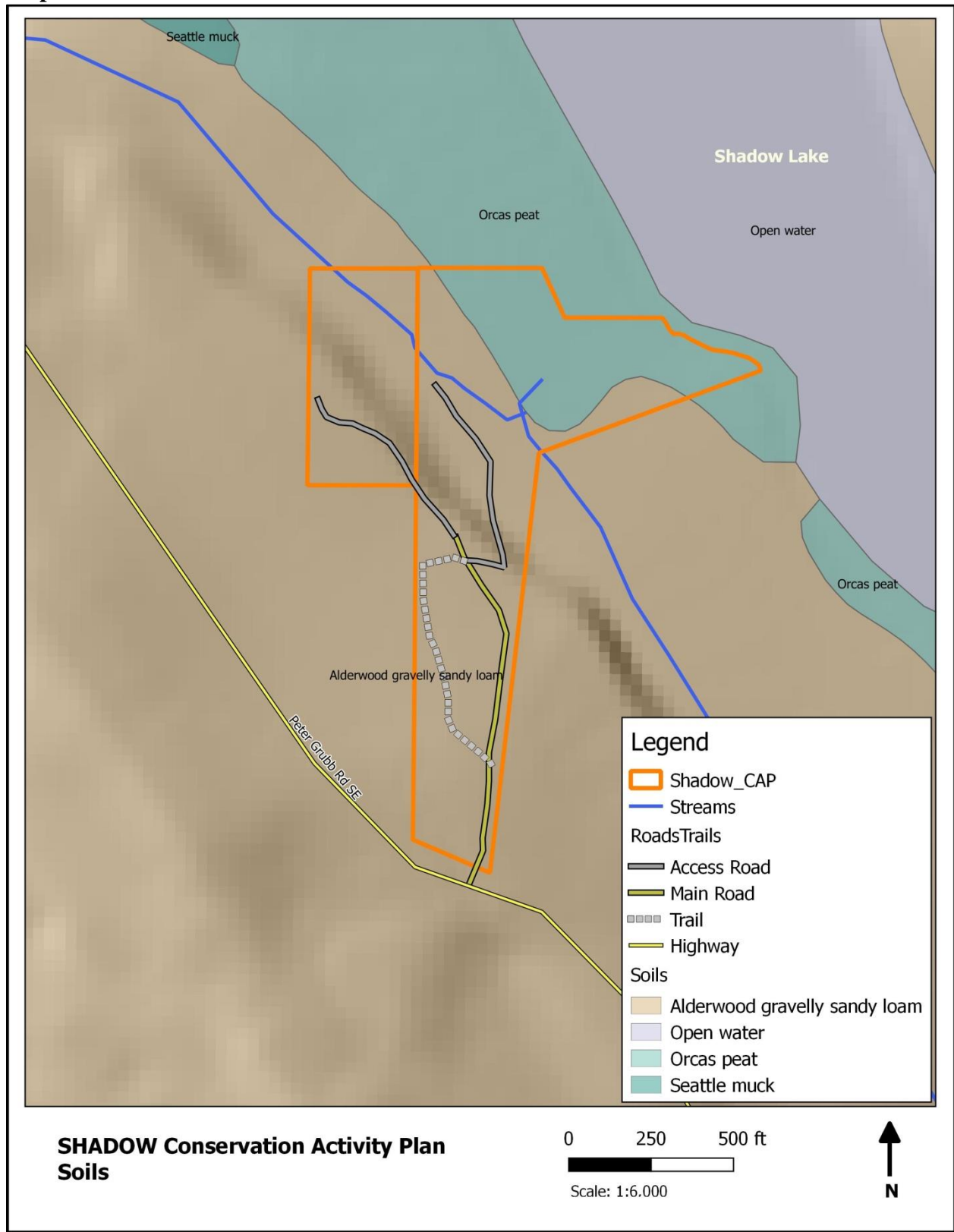
The landowner should monitor and control invasive species every 1 to 3 years to identify the effectiveness of previous treatments and new problems.

Wildfire Risk Mitigation

While wildfire risk is associated with drier ecosystems east of the Cascade mountains, wildfires can and do occur on the west slope of the Cascades. Furthermore, climate change predictions indicate drier, longer summers increasing the risk of wildfire. Preparing for wildfire will reduce the risk of catastrophic loss of forest land and property.

Improve road access so that main roads and side trails are accessible to high-clearance 4-wheel drive vehicles so that fire response teams can enter the property and conduct fire control operations if needed. Road maintenance includes regular branch trimming and mowing of existing trails. Road grading or additional rock may be necessary in the case of erosion and washouts, but at this time the gravel road bases are in good condition.

Map 4: Soils



D. Resource Category II: Soils

Resource Conditions

Alderwood gravelly sandy loam soils cover the entirety of the upland forested area of the SHADOW Forest. Orcas peat covers the remainder of these parcels, supporting bogs and forested wetlands. See the map below and the attached Soils Report for more details.

Alderwood soil was deposited when the last glacier advanced over the region. The soil originated from glacial till and has an average soil depth of 20-40 inches and an organic layer of 1-3 inches. It is moderately well drained, but has a restrictive layer of glacial till that slows permeability and keeps rooting depth to 20-40 inches. Flooding potential is low, but erosion hazard is moderate to severe. These soils can support a wide range of tree species. Douglas-fir and red alder tend to dominate these soils, although western hemlock and western red-cedar grow equally well. Tree growth potential is moderate to high, with a Douglas-fir, 50 year site index of 111. Competition from brush and hardwood species is intense. Wind-throw potential is moderate. They are moderately resistant to compaction.

Orcas peat is a plant-derived soil that develops in lowlands and depressions. The soil is entirely peat. Orcas peat is hydric, frequently ponded and very poorly drained soil. Depth to water table is zero inches. These soils are not suitable for logging. Soils are low-strength and are poorly suited or severely poorly suited to logging roads, landings, and soil rutting.

Management Practices

Logging can only take place on Alderwood soils. Logging activities, if taken, should occur in the dry summer months to avoid unnecessary soil disturbance, rutting, and compaction. Use existing roads and trails to the extent possible. Limit haul roads and landings to minimize compaction. Orcas soil is not suitable for logging.

E. Resource Category III: Water Quality, Riparian and Fish Habitat, and Wetlands

Resource Conditions

The SHADOW Forest is located within the Green-Duwamish River watershed at the Hydrologic Unit Code 12 (HUC 12) level. This means that water on the property drains to the Green River, ultimately to Puget Sound at Elliot Bay in Seattle.

Expansive sphagnum bogs are the most unique hydrologic resource on the property. Additionally, forested wetlands with red alder, shrub-scrub wetlands with willow and other species are located in the northeastern eastern portion of the parcels. The wetlands adjoin Shadow Lake, and a tributary to Jenkins Creek crosses the property. Shadow Lake drains to the Green River at Auburn, WA via the tributary to Jenkins Creek, to Jenkins Creek, and Big Soos Creek. Shadow Lake is an “S” type water body under the WA DNR rating system.

A non-fish bearing tributary stream runs from the property’s northmost point to the southeast. The riparian zone is wide and heavily vegetated, with inundated portions average 14 feet bank to

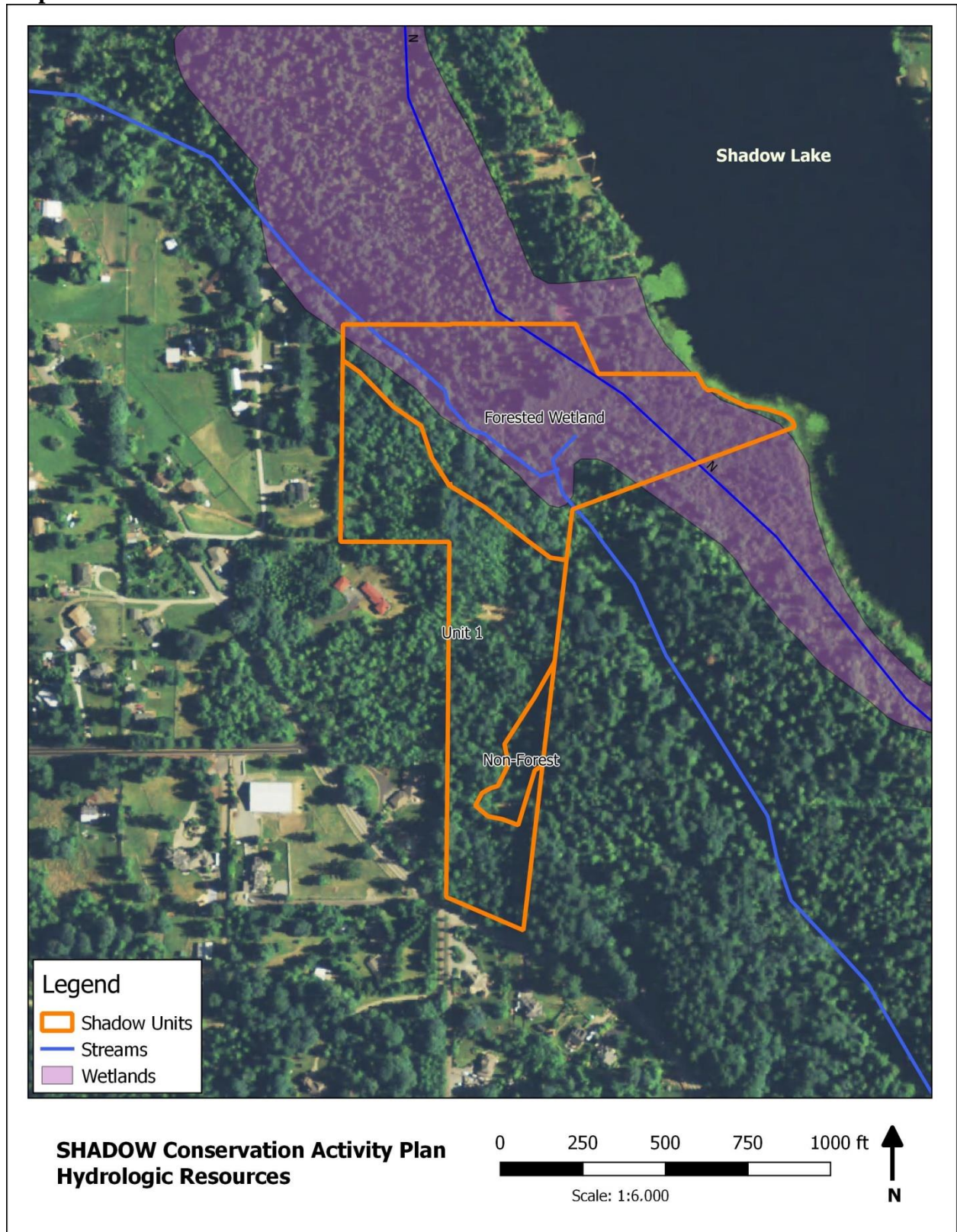
bank including vegetation, but the saturated zone extends approximately 50 feet edge to edge. Water is slowly moving and tannic brown. Mixed species forest including red alder and red cedar extend to the riparian edge on both sides. The stream widens and ultimately dissipate into the bog on the north east portion of the property. Another stream is shown on King County stream database in the northeast corner of the property, listed as non-fish bearing stream in the DNR database, but that could not be verified in site visits because the wetlands were impassable.

King County does not identify any non-wetland critical areas, including Critical Aquifer Recharge Areas,

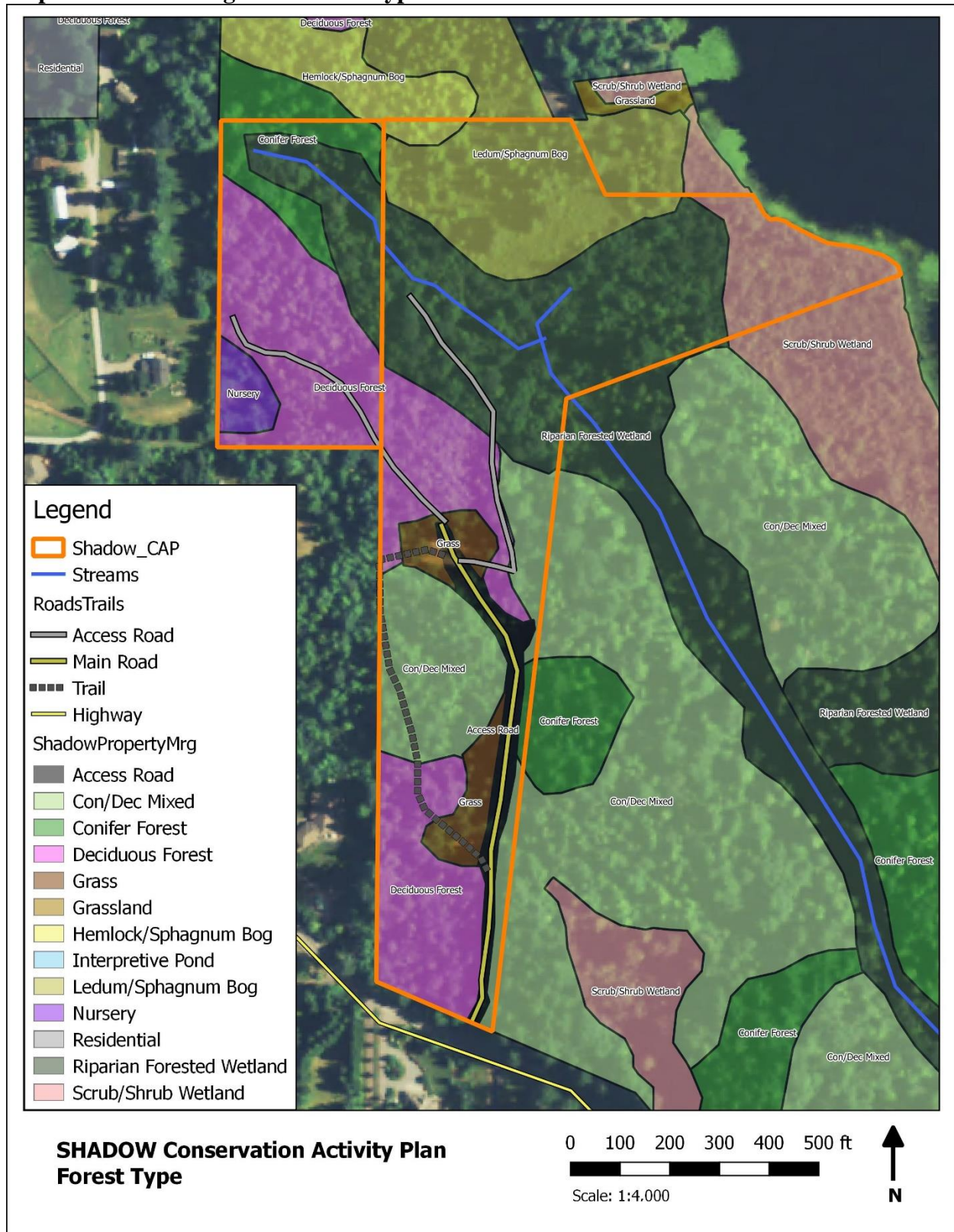
Management Practices

Maintain an equipment limitation zone within 50 feet of the wetland boundary to prevent rutting, soil compaction, and disturbance of wetland communities. Observe Forest Practices riparian management zones (RMZ) along Jenkins Creek and its tributaries. The RMZ includes a 50-foot no-cut buffer. The landowner may be able to thin trees between 50 and 200 feet from bankfull width depending on how many and how large the trees are when submitting a permit to the DNR. The buffers will be based on a Site Class III, according to the WA DNR site class information.

Map 5. Water features for SHADOW Forest.



Map 6. Forest and vegetation cover types



F. Resource Category IV: Forest Inventory

The SHADOW property consists of two upland forest types (8 acres young hardwood, and 2 acres mature mixed conifer-hardwood) and two forested wetland types (6 acres of lowland hardwood forest, and 2.5 acres of forested bog). 1.5 acres of shrub/scrub wetland is located adjacent to Shadow Lake. Non-forested grassy openings, roads, and a plant nursery compose the remaining 2 acres. The hardwood upland forest type is dominated by 15-year old red alder. This forest type originated from a clearcut harvest around 200. Naturally regenerating red alder overtook the forest species composition. The second forest type is a relatively small patch of second-growth mixed conifers with a more diverse species composition and an older stand age. The lowland hardwood forested wetland includes a red alder forest similar in age and composition to the upland red alder forest type, but located on hydric soils. The second forested wetland is a low-density hemlock-Douglas fir forest located on sphagnum peat soils.

Forest Survey and Inventory Methods

Data for this management plan were collected in May 2016. Seven fixed radius plots that measure 1/20th of an acre were established based on a stratified random grid, at a sample rate of about one plot per 2.5 upland forested acres. Within these inventory plots, all living and dead trees greater than 5 inches diameter at breast height (DBH; measured at 4.5 feet above the ground) were recorded. We also recorded the species of tree, height, crown ratio, age, damage, and tree health. Live trees less than 5 inches DBH were counted within the 1/20th acre plot.

We also assessed percent cover of shrubs and ground vegetation to the nearest 5% within a 1/50th acre sub-plot, centered on the tree plot center. General observations about forest condition and notable features and resources were recorded at each plot and throughout the forest.

Given inoperable conditions and forest management objectives to protect forested wetlands, forest inventory focuses on the 10-acre upland forested area that includes a majority young alder forest, with a 2 acre patch of mature mixed conifer-hardwood forest. This upland area is designated Unit 1.

1. Resource Conditions

Unit 1: Hardwood Forest with Patches of Mature Mixed Conifer-Hardwood Forest

Unit 1 is characterized by small diameter, dense, even-aged red alder, with lesser amounts of black cottonwood and bigleaf maple. There are a few conifer species scattered throughout this stand, such as Sitka spruce and western redcedar, however, red alder dominates. A 2-acre patch of mixed mature and young hardwoods and conifers occurs in the southern portion of the unit. Despite this, small-diameter red alder define the management unit.

There is currently very limited regeneration of tree species in this stand and the understory is dominated by well-developed salmon berry and Himalayan blackberry, reaching eight feet tall in some locations. Stand density is not moderate, and the dense shrub layer will continue to limit

tree regeneration and productivity. Individual tree growth is moderate to low, with many of the red alders, particularly in the north part of Unit 1, having broken tops with rearticulated leaders.

Table 2: Unit 1 density metrics, per-acre results, including established trees (DBH>5")

TPA	TPA >5"	QMD	QMD >5"	BA	BA >5"	Volume (Gross MBF)	Site Index (soil survey)
326	251	8.0	8.7	113	101	7.4	111

The impenetrable thicket of thorny shrubs provides habitat for some wildlife species, such as deer and birds, but also prevents tree regeneration. Vertical structure is limited by the height of the existing trees, which averages approximately 30 feet. Overall, there is a lack of large woody debris in this stand.

Height-to-diameter ratios are poor, averaging 85. This indicates that the trees are currently over stocked and growing in dense conditions, competing with each other for sunlight by maximizing height growth at the expense of diameter growth.

Table 3: Per-acre stand density characteristics by species

Species	TPA	BA	QMD	Volume (MBF)
RC	20	21	13.8	1.6
RA	170	39	6.5	1.1
DF	10	15	16.7	2.4
WH	5	10	18.8	1.1
BM	70	13	5.9	0.2
CW	20	11	10.0	0.8
OT	30	4	7.1	0.2
Total	326	113	8.0	7.4

RC= western redcedar, RA= red alder, DF = Douglas-fir, WH = western hemlock, BM = bigleaf maple, CW = cottonwood, SS = Sitka spruce, OT = other species

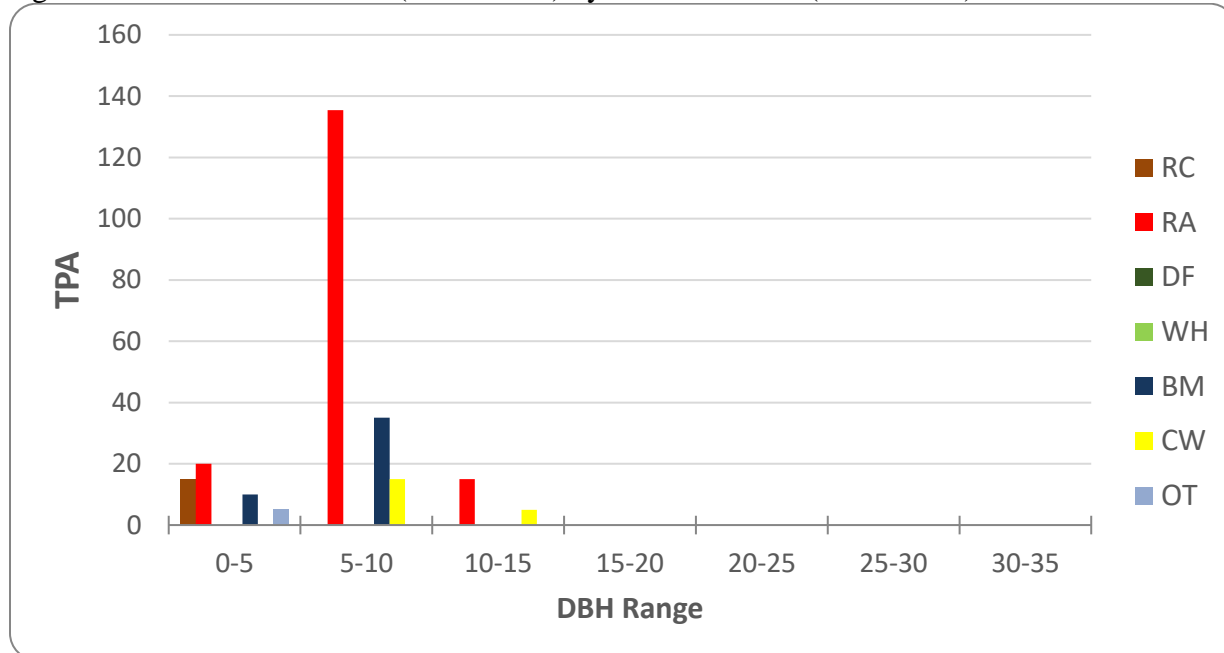
Similarly, trees per acre (TPA) also indicates dense conditions. TPA averaged 326 for all trees. TPA ranged from 201 to 521 per plot. Illustrating relatively low volume, basal area (BA) is 113 square feet per acre (ft²) for trees greater than 5" DBH with a quadratic mean diameter (QMD; a calculation of the diameter of the tree with average basal area) of 8.0 inches. The mature trees in the 2-acre patch bring up the stand average; much of the unit has lower BA and smaller QMD.

Red alder dominates this forest stand type and is the most important species in terms of both TPA and BA.. The average height for the largest hardwood trees was 53 feet, with the tallest hardwood tree (a cottonwood) measured at 79 feet. A sample of trees was cored to determine

age. Ages at breast height ranged from 15-18 years old in the young alder area. We estimate the stand age is approximately 20 years, given several years of growth can take place below the point on the tree where age is measured. This estimate places the harvest year in 1995. The site index for this unit is 111 based on the soil survey.

The more mature patch of mixed species is dominated with western redcedar and Douglas-fir, with much higher basal area and QMD (233 ft² and 21.3 inches, respectively). This patch includes trees as old as 78 and exhibits better mixing of tree species and tree heights than the ballast of the unit.

Figure 1: The number of trees (Tree Count) by Diameter class (DBH Class) for trees in Unit 1.



Spatial diversity such as mixtures of tall and short trees, areas with high density, and other areas low density is lacking in the alder-dominated areas of the unit. This stand has low species diversity and is deficient in conifers.

In the absence of active forest management, this unit will continue to have stagnant growth due to the under-stocked and dense conditions and will likely deteriorate over time. Competition-induced mortality and low vigor are taking place in many areas of the stand. These conditions will prevent individual trees from achieving merchantable volume and the large sizes that maximize their wildlife value. Without active management, forest composition will likely remain dominated by hardwoods, such as red alder. New tree recruitment will not occur or will occur at very low rates due to the very well developed shrub layer and the high levels of competitive between trees. Wind disturbance could change the composition of the forest in the long-term by

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killing or damaging patches of trees. These areas would become canopy gaps, hotspots for natural regeneration but would likely remain in shrub thickets.

Given the age, forest health, and density issues, current timber production is poor in this stand. However, if the management recommendations below are implemented, this unit could have high wood product potential and greatly improved wildlife habitat in 20 to 30 years.

Desired Future Conditions

Guidelines for density, tree size, and spatial distribution of this forest type are taken primarily from the Franklin et al. (2002) article on western Cascade conifer forest stand development. The desired future condition is a late-seral mixed hardwood-conifer forest, including long-lived large trees with strong growth that will maximize wildlife value. This includes management that mimics natural disturbance patterns, enhancing growth of large-trees, increasing tree and shrub diversity, and spatial heterogeneity. Species diversity increases habitat niches and provides water retention and drought tolerance, resilience to changing climate, diseases, and timber markets. A diverse shrub layer will include a mix of native species.

Specifically,

In 10 years: Individual tree growth and health are strong. Conifer trees are increasing in abundance, gaining good position in the canopy and experiencing rapid growth. High TPA values around 300 reduce the risk of Himalayan blackberry dominance in the understory, and provide good growing conditions for trees. BA will increase rapidly.

In 20 years: Trees increase in diameter, height, and proportion of live crown. Small-scale disturbance thins the forest, allowing the remaining trees to continue strong growth. TPA reduces due to competitive mortality to around 180, with BA at 150-200 ft² per acre and average DBH of about 12 inches.

30 years and beyond: Canopy gaps open up, removing some hardwoods but retaining most of the conifers. In the gaps, regenerating red cedar and hemlock with Douglas-fir and spruce or white pine emerge, with limited red alder, bigleaf maple, and cottonwood emerge from shrub layers to establish a strong new cohort. The forest will have maturing conifers, a variable canopy of mixed conifers with hardwoods interspersed individually and in clumps, and canopy gaps with robust shrub and forb communities with regenerating tree species. Large (>12" diameter) logs and snags become common.

. Resource Concerns and Forest Issues Preventing Desired Future Conditions

The main issues jeopardizing the desired future conditions include degraded plant condition due to undesirable plant productivity and health, and inadequate structure and composition due to the stunted regeneration and lack of canopy layers. Invasive species, particularly Himalayan blackberry can impede desired future conditions.

Figure 2. Photographs of the Hardwood forest type illustrating the small average tree diameter



Forested Wetlands

Forested wetlands include lowland hardwood forests, riparian forests, and forested bogs. These forest types are sensitive or rare habitat types. Logging is not suitable in these forests.

Lowland hardwood forests are located on saturated soils. Red alder is common at low densities, frequently establishing on hummocks. Bigleaf maple and willow are also present. Vine maple is abundant. This forest type transitions to a scrub/shrub wetland dominated with willow, scrub alder, and salmonberry.

Riparian mixed conifer-hardwood forests are located along Jenkins creek and its tributary. Within regulatory no-cut riparian management zones, these forests include larger western redcedar with some western hemlock and Douglas-fir.

Forested bogs include low densities of mature western hemlock and Douglas-fir clustered amid shrub openings.

Figure 3: Forested wetland with vine maple and red alder



Figure 4: Forested bog



Figure 5: Scrub/shrub vegetation type



2. Management Practices and Timeline

The forest land on this property is in poor to fair health with some areas exhibiting low vigor, low species diversity, high amounts of invasive species and is recovering from previous harvest activities. However, Unit 1 has good growth potential and will benefit from a variety of thinning strategies in the near future in order to improve forest health and increase tree vigor.

Unit 1 Management Recommendations

2016-2026: Non-Commercial Thin, plant, and shrub control.

Reduce stand density in red alder and cottonwood to about 30% of original density to maximize individual tree health, vigor, and growth; create openings to re-initiate sun-dependent long-lived conifers; and aggressively remove invasive species. Retain conifers and bigleaf maple. Enact shrub control to promote seedling vigor.

- **Heavy Non-commercial thin:** red alder removal. Retain 30% of existing canopy in clumped distribution.
 - Retain most vigorous RA, CW and BLM with good height to DBH ratios
 - Retain all conifers
 - Create openings up to 1 acre
 - Retain native shrubs near retention trees
 - Lop and scatter, or masticate slash
 - Or, create windrows of slash to protect seedlings
- **Plant mixed conifer seedlings**
 - In openings, plant tightly to shade out weeds, approximately 400 trees per acre. Plant Douglas-fir, red cedar, Sitka spruce, and western hemlock. Anticipate natural red alder regeneration.
 - Let planting shade out shrubs in medium term (10-15 years)
- **Shrub control**
 - Follow up planting with shrub control in the first five years. Conduct shrub control if needed. See Job Sheet 314 – Brush Control for details.
- **Weed control**
 - Mechanical and herbicide as appropriate
 - Follow up for several years, until canopy closure

2026-2036: PCT and Forest Maintenance

- **PCT with variable spacing**
 - Reduce stand density to about 200-250 TPA, retaining conifers and vigorous hardwoods. Thin with irregular spacing to promote clumping: do not thin to even spacing.
- **Forest Maintenance**
 - Locate and treat invasive species where they exist. See Job Sheet 315 – Weed Control for details.
 - Maintain roads and trails through vegetation management and grading.
 - If canopy gaps occur, underplant with up to 150 TPA native conifers.

2036-2046: Commercial thin with variable density and skips and gaps.

Thin to 110 TPA/125ft² BA, removing mostly mixed species based on individual tree vigor and health, cutting through the diameter range. Retain the largest 20% of trees to promote a backbone of old-growth trees.

- Retain diverse species, vigorous growth, and patchy spatial distribution. Include dense clumps and open areas.
- Retain natural regeneration and plant in canopy gaps as needed.
- Retain ~5 wildlife trees per acre. Wildlife trees are 12”+ DBH with broken tops, bole damage, or complex crowns that provide good wildlife habitat.

Gaps:

- Cut canopy openings in 10-15% of the forested area (~1 to 1.5 acres) in gaps ranging from ¼ to 1 acre in size. Cut all trees. Select gaps to avoid cutting the largest 20% of trees to promote a backbone of old-growth trees.
- Replant gaps with 200 TPA, adjusting planting mix to accommodate foreseeable shifts in regional weather patterns. Include western redcedar (protect with plastic mesh sleeves), western white pine, Douglas-fir, Sitka spruce, and/or bigleaf maple. Expect western hemlock and red alder natural regeneration

Skips:

- Select 5-10% of the forested area (~0.5 to 1 acres) in no-cut skips. These skips provide density for more habitat niches and visual screens.

Forest Maintenance

- Locate and treat invasive species where they exist. See Job Sheet 315 – Weed Control for details.
- Maintain roads and trails through vegetation management and grading.
- If canopy gaps occur, underplant with up to 150 TPA native conifers.

Forested Wetland Unit Management Recommendations

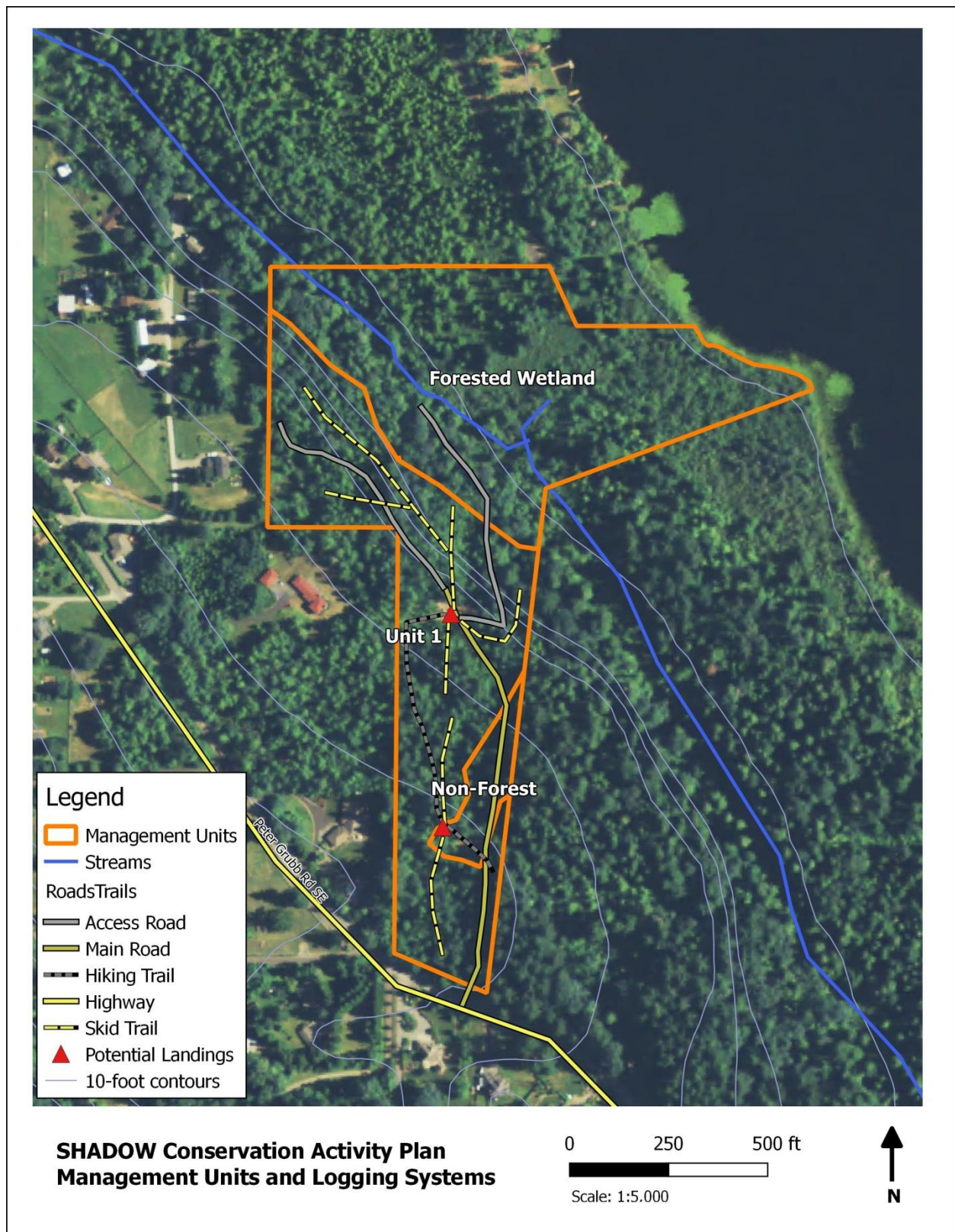
Locate and treat invasive species where they exist. See Job Sheet 315 – Weed Control for details.

3. Harvest Operations

Ground-based commercial logging is suitable for Unit 1. Low-impact equipment, such as a compact tracked shovel, forwarder, or processor is the most suitable equipment when harvesting and thinning. This type of equipment does not require wide skid roads and, when implemented appropriately, can minimize site impacts. Soil compaction and erosion are concerns in and around the property and therefore skid roads need to be appropriately located in the driest of areas.. If signs of erosion occur, 4 to 6 inches of straw should be applied to the area to decrease surface runoff and native species (e.g., salmonberry, salal, and native grasses) should be planted to stabilize the soil. Driving machinery on hydric wetland soils should also be avoided. Using two landings located at existing openings keep logging impacts low.

For the variable density thin in 2045, marking individual trees for harvest may be useful. For mixed species and mixed diameter thins it is difficult to prescribe tree selection in an easy and reproducible way for the logger. In this situation a forester marks trees to be cut with orange paint to facilitate logging and ensure the logger reaches the desired outcome. Alternatively, allowing the logger to select his cut trees could result in a good outcome but requires close oversight of the logging operation and trust between the logger and land owner.

Map 7. Forest Management Units and Logging Systems



4. Outcome of Recommended Prescription

Table 4: Per-acre results of recommended prescription. Results are generated using the Forest Vegetation Simulator (FVS, Dixon 2002), a forest growth model that uses inventory data and site-specific parameters to project forest growth in response to forest management scenarios.

Year	Rx	Pre-Treatment				Post Treatment				Removals			Removals - %		
		TPA	BA	QMD	MBF	TPA	BA	QMD	MBF	TPA	BA	MBF	TPA	BA	MBF
2016	Non-Com Thin, plant	326	113	8.0	7.4	97	81	12.4	7.4	228	31		70%	27%	
2026	PCT 2031	454	108	6.6	21.7	200	107	9.9	21.7	254	1		44%	1%	
2036	None	193	140	11.5	30.3										
2046	Thin to 110 TPA	184	174	13.2	39.2	111	124	14.3	29.8	73	50	9.4	40%	29%	24%
2056	None	107	151	16.1	37.7										
2066	None	102	179	17.9	49.2										

5. Management Plan Implementation Time Table with Job Codes

Unit	Acres	Year 0-10 (2016-2026)	Year 10-20 (2026-2036)	Year 20-30 (2036-2046)
Unit 1	10	<p><u>Non-commercial thin.</u> By 2020, thin to 100TPA/80ft² BA (range +/-30 TPA). Generally thin from below. Retain all conifers and healthiest, most vigorous RA, CW, BM. Thin with variable spacing.</p> <ul style="list-style-type: none"> • Create canopy gaps totaling 1-1.5 acres. Remove all trees. Select gaps in areas without mature trees. • Retain no-cut skips totaling 0.5 to 1 acre • Replant open areas with 400TPA with a mix of RC,WH, DF,WWP,SS • Lop-and-scatter slash • Shrub Control up to 5 yrs following planting • Monitor for and remove invasive species 	<p><u>PCT.</u> By 2035, thin stand density to 200-250TPA retaining mixed species of vigorous conifers hardwoods. Thin with variable spacing.</p> <ul style="list-style-type: none"> • If canopy gaps occur >1/4 acre, Replant gaps with 200 TPA RC, DF, WWP,SS, and/or BM. • Monitor for and remove invasive species 	<p><u>Variable Density Thin.</u> By 2046, thin to 110TPA/BA 120 (+/- 40 TPA). Retain mixed species with good health and deep crowns, cut through DBH range. Retain the largest 20% of trees</p> <ul style="list-style-type: none"> • Create canopy gaps totaling 1-1.5 acres. Remove all trees. Select gaps in areas without mature trees. • Retain no-cut skips totaling 0.5 to 1 acre • Retain no-cut skips totaling 0.5 to 1 acre • Retain ~5 wildlife trees/acre. • Replant gaps with 200 TPA RC, DF, WWP,SS,and/or BM. • Lop-and-scatter slash • Shrub Control up to 5 yrs following planting • Monitor for and remove invasive species.
Job Codes		666NCT: Forest stand improvement	666PCT: Forest stand improvement	666VDT: Forest stand improvement
		384: Woody residue treatment	612: Tree/shrub establishment	384: Woody residue treatment
		612: Tree/shrub establishment	314: Brush management	612: Tree/shrub establishment
		314: Brush management	315: Herbaceous weed control	314: Brush management
		315: Herbaceous weed control		315: Herbaceous weed control

6. Financial Analysis

The management recommendations provided in this section are founded in conservation-oriented strategies. However, the financial component of these management actions is a critical aspect to feasible implementation. Planting, shrub control, and invasive species control will require cash outlays. The table below details the costs and revenue associated with the management recommendations.

Table 6: SHADOW Forest – Financial Estimate through 2046. Estimate does not include EQIP cost sharing.

Activity	Year	Acres	Cost/ acre	Total Cost/Rev	NPV (6%)	Notes
Non-commercial thin	2016	10	\$285	-\$2,850	-\$2,850	
Slash treatment	2016	10	\$285	-\$2,850	-\$2,850	
Plant	2017	5	\$600	-\$3,000	-\$2,830	Plant 400TPA in gaps only, 50% of unit. Includes seedlings, labor, browse protection for 20% of seedlings
Shrub/invasives control	2017	5	\$110	-\$550	-\$519	Mechanical/Herbicide, assume 50% of unit needs treatment
Shrub/invasives control	2018	5	\$110	-\$550	-\$489	Mechanical/Herbicide, assume 50% of unit needs treatment
Shrub/invasives control	2019	2.5	\$110	-\$275	-\$231	Mechanical/Herbicide, assume 25% of unit needs treatment
PCT	2031	10	\$285	-\$2,850	-\$1,189	
Plant	2031	1	\$300	-\$300	-\$125	Plant 200TPA in gaps only, 10% of unit. Includes seedlings, labor, browse protection for 20% of seedlings
Shrub/invasives control	2031	2	\$110	-\$220	-\$92	Mechanical/Herbicide, assume 20% of unit needs treatment
Shrub/invasives control	2032	2	\$110	-\$220	-\$87	Mechanical/Herbicide, assume 20% of unit needs treatment
Commercial thin	2046	10	-	\$10,591	\$1,844	See Detail Sheet below, includes all costs associated with harvest.
Slash treatment	2046	10	\$285	-\$2,850	-\$496	
Plant	2046	2	\$300	-\$600	-\$104	Plant 200 TPA gaps only, 20% of unit. Includes seedlings, labor, browse protection for 20% of seedlings
Shrub/invasives control	2047	2	\$110	-\$220	-\$36	Mechanical/Herbicide, assume 20% of unit needs treatment
Shrub/invasives control	2048	2	\$110	-\$220	-\$34	Mechanical/Herbicide, assume 20% of unit needs treatment
Shrub/invasives control	2049	1	\$110	-\$110	-\$16	Mechanical/Herbicide, assume 10% of unit needs treatment
30-Year Total				-\$7,074	-\$10,105	

Table 7: SHADOW Forest cost/revenue detail of 2046 variable density thin

Estimated Revenue - Unit 1 Variable Density Thin 2046				
	10	Acres	9.4	MBF/Ac
Revenue	% of Cut Logs	Total Volume (MBF)	Price/ MBF	
Red Alder	30%	28	\$600	\$16,920
Hemlock-Spruce-Pine	30%	28	\$450	\$12,690
Douglas-fir	5%	5	\$550	\$2,585
Bigleaf maple	5%	5	\$400	\$1,880
Pulp (\$30/Ton, 5 Tons/MBF)	20%	19	\$150	\$2,820
Total Revenue				\$36,895
Costs				
Ground-based logging		\$150	/MBF	\$14,100
Trucking		\$100	/MBF	\$9,400
Road clearing, grading, and spot rock				\$1,000
DNR Permit Fee				\$150
Forester's fee - 5% of log sales				\$1,481
5% DNR harvest tax of net revenue				\$174
Total Costs				\$26,304
Net Harvest Revenue				\$10,591

Interpretation of Financial Analysis

This prescription will require costs from year 1. The forest won't have sufficient ecological need or board foot volume for a profitable harvest until 2046. That harvest will generate a profit given costs and revenues remain proportional. Seeking cost sharing from the NRCS EQIP program will substantially reduce the landowner's financial burden.

G. Resource Category V: Property Access, Roads, and Trails

Resource Conditions

Public access to the subject property is from the south along Peter Grubb Rd SE. There is a gate that allows pedestrian passage onto the property. The gravel road leading into the property is in good condition, leading for about a quarter mile to an opening. From there, natural surface roads extend to the north and to the west. A hiking trail also originates here, looping to the west and south.

Both the main access road and old skid roads can support logging equipment with some improvements that are highlighted below. The roads are suitable for accessing the property for fire or forest management purposes.

Management Practices

The main access road and existing skid trails should be regularly maintained by regular branch trimming and mowing. Grading and additional spot rock will be needed in advance of timber harvest. These forest roads and skid trails can provide vital access to the property in case of fire and will provide access for other recommended forest management activities identified in section F, Resource Category IV: Forest Inventory. Hiking trails can be improved with regular trail clearing.

H. Resource Category VI: Wildlife

The property is an active place for a number of wildlife species including small mammals, deer, song birds, raptors, amphibians, reptiles, and invertebrates. The property also provides important ecosystem services such as wildlife habitat and regulating local hydrology, which drains into nearby Shadow Lake. The forest vegetation slows water runoff and allows it to filtrate through the soil, thereby minimizing potential erosion. There are also a few relatively large Douglas-fir and western redcedar trees on the property. These mature trees were left by previous loggers due to their defects – likely because of their poor form and high likelihood of rot. These veteran trees provide important features for wildlife species such as cavity nesting sites and food resources, which are particularly important for birds like woodpeckers and sapsuckers. Snags also help create vertical structure in forests and can remain standing for decades. These features should be retained and protected. The most important management decision regarding the wildlife habitat will be the timing, frequency, and intensity of forest management activities. The retention of the snags, large down logs, and larger diameter trees will be important in order to maintain the current richness of biological diversity. Large trees with complex crowns have high wildlife value because they can have large trunk cavities, nesting surfaces in large and complex crowns, better snags and downed logs, and more resistance to defoliators. It is important to maintain a matrix of diverse habitat types, species composition, and forest structure throughout the property, which all provide important wildlife benefit.

The high amount of salmonberry and Himalayan blackberry shrubs in the understory provide limited habitat for wildlife. The dense cover and prolific berries are good songbird and small mammal habitat, but lack a breadth of food sources that sustain species throughout the year. Transitioning the understory to include more trees, shrubs, forbs and grasses that produce seeds, berries, nuts, leaves, bark and twigs are important wildlife habitat components providing food, shelter, and nesting habitat. Valuable wildlife species include red alder, red elderberry, salal willow, thimbleberry, hazelnut, vine maple, and Oregon-grape.

Adjacent forested wetland and bogs provide unique and valuable habitat for a variety of species. Sphagnum bogs host unique flora due to their acidity, lack of nitrogen, and vegetal soils.

Management Practices

Maintaining and increasing large diameter trees, snags, and coarse woody debris are key wildlife objectives. Increasing the tree species diversity including hardwoods will also improve wildlife habitat. Thinning to promote large, vigorous trees and gap creation coupled with replanting diverse tree species will accomplish this goal over 1 to 3 decades. Removing the invasive Himalayan blackberry in increasing shrub diversity will further improve wildlife habitat. The management recommendations in Resource Category IV: Forest Inventory are designed to improve wildlife habitat quality.



Hemlock-Labrador tea-sphagnum plant association on SHADOW forest, an imperiled habitat type in Washington State.

I. Resource Category VII: Protection of Special Resources

1. Threatened and Endangered Species

No documentation of any species of concern is recorded for SHADOW forest or adjacent properties based on the Washington Natural Heritage Program (WNHP) database of current and historic unique, rare, and protected species. White-top aster (*Sericocarpus rigidus*) was observed 1.5 miles southwest of the property. White-top aster is listed as Sensitive in Washington State and Species of Concern federally¹. White top aster grows in clumps and reaches about a foot tall.

¹ http://file.dnr.wa.gov/publications/amp_nh_seri4.pdf

Its habitat is open flats below about 500 feet elevation; SHADOW does not have suitable habitat for this species.

A western hemlock – (western redcedar)/bog Labrador-tea/sphagnum spp. habitat type is recorded 2 miles north of SHADOW forest. Although not recorded in the WNHP database, this habitat type also occurs on SHADOW property in the bogs adjacent to Shadow Lake. This habitat type is listed as an imperiled habitat (rank S2) in Washington State but is not recognized federally. Similarly, western hemlock - (western redcedar)/sphagnum spp. plant association is not listed in the WNHP database but occurs on the property. This habitat type is listed as critically imperiled (rank S1) and is also not recognized federally.

2. Cultural Resources

Native Americans relied on salmon-bearing streams and lakes such as Jenkins Creek and Shadow Lake, and adjacent uplands for food and forage, though no cultural resources are known to occur on the property, and no cultural resources were observed during field visits.

Management Practices

Do not conduct logging operations in or within state-regulated buffers of bog habitats to protect these sensitive and rare resources. IF cultural resources are discovered at any time report them to the State Historic Preservation Office.

The forest management practices described in Resource Category IV: Forest Inventory are designed to improve old-forest dependent wildlife habitat over a long timeframe (30+ years). Generally, maintaining forest cover, increasing large-diameter long-lived trees, increasing large-diameter snags, and creating patchworks and multi-story canopies of diverse, multi-age trees will create and improve habitat for a wide variety of species.

J. Resource Category VIII: Aesthetics and Recreation

Resource Conditions

SHADOW has a unique educational component to its mission, including buildings and staff dedicated to school groups and community outreach. Respectful visitor participation enhances the community's appreciation of the unique bog and forest habitats. This property is open to low-impact public passive recreational uses such as walking, dogs-on-leash, and wildlife-viewing. Pedestrian access leads from Peter Grubb Rd SE into the property. Hiking trails extend into adjacent parcels. SHADOW has a plant nursery on the northwest end of the property dedicated to useful native plants that youth and community groups visit. SHADOW is considering linking this property to its main educational facility to the north via a hiking trail.

Management Practices

Maintain roads and paths for pedestrian access. Maintain signage to enhance user experience. If logging takes place, use the signboards as an opportunity to reach out to Preserve users explaining the ecological rational and desired future conditions of the management activities.

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L. Glossary

Basal Area	BA - The cross-sectional area of a tree at breast height (4.5 feet from the ground). BA is also used to mean basal area per acre (BAPA or BA/Ac).
Coarse Woody Debris	CWD – Large-diameter dead wood on the ground.
Cohort	A group of trees that established at the same time, typically after disturbance such as clearcut logging, fire, or blow down.
Diameter at Breast Height	DBH – Tree diameter at 4.5 feet from the ground on the uphill side of the tree. This is the standard for tree diameter measurements.
Dominant	An individual or set of trees whose crowns occupy the upper position of the canopy.
Emergent	Trees that break through (emerge) from the canopy of dominant trees in a stand.
Green Wildlife Tree	A live tree that provides good wildlife habitat, such as cavities on the trunk, large branches, or complex canopy structure.
Hazard Tree	Hazard trees include dead trees, trees that are clearly stressed due to disease or damage, trees with weakly connected branches, tops or stems, and any other tree that poses the increased risk of falling and damaging property or injuring people.
Height to Diameter Ratio	HDR - Tree height divided by tree DBH, and indicates the competitive conditions in which a tree developed. High HDRs, where trees are very tall relative to their girth, indicate trees that grew in crowded conditions, allocating energy to height. Open-grown trees tend to have low HDRs. High HDRs correlate to increased risk of windthrow.
Live Crown Ratio	LCR - The ratio of live canopy to the total height of the tree. For example, if a 100' tall tree has a live crown in the top 45' and bare trunk for the remaining 55', the tree has a live crown ratio of .45 or 45%. Crown ratios of .5 and greater are considered healthy; ratios of less than .3 are very unhealthy. This may also be expressed as the percent live crown.
Thousand-Board-Foot	MBF - A measurement of timber volume; one board-foot (BF) equals the volume of wood in a plank one inch thick, one foot long, and one foot wide (i.e., 1" x 12" x 12"). Thousand-board-feet is a common unit because of the large volume of timber in a typical stand. The "M" in MBF refers to <i>mille</i> , Latin for "thousand."

Patch	A patch is an area within a stand. Patches typically call out a distinction in forest type that is at too fine of a scale to be considered its own stand.
Quadratic Mean Diameter	QMD - A calculation of the diameter of the statistical tree with average basal area.
Relative Density	RD - Basal area divided by the square root of the QMD, and indicates the proportion of biomass relative to a theoretical maximum biomass of 100.
Release	A method of thinning where surrounding trees are removed from a desired tree, with the intention of increasing the released tree's health and vigor.
Stand	A grouping of trees into a logical management unit typically based on consistency in factors such as species composition, age, topography, aspect, disturbance history, or natural or artificial boundaries like a river or a road. Can be used interchangeably with "unit."
Thin	To harvest a portion of the trees in a stand. Harvest may or may not include sale or profit from trees.
Thin from Below	A method of thinning where the smallest trees in terms of diameter or height are removed, leaving the biggest and typically healthiest trees.
Trees Per Acre	TPA - The average number of trees per acre calculated from a sample of plots within the stand.
Unit	A specific forestry management unit typically based on consistency in factors such as species composition, age, topography, aspect, disturbance history, or natural or artificial boundaries like a river or a road. Generally interchangeable with "stand."
Variable Density Thin	VDT - A method of harvest based on the retention of trees in patterns other than regular spacing, involving patchy or irregular distribution of retention trees.
Variable Retention Harvest	VRH - A method of harvest based on the retention of structural elements or biological legacies (trees, snags, logs, etc.) from the harvested stand for integration into the new stand to achieve various ecological objectives. Typically, small to large gaps create areas for stand reinitiation. Major variables are types, densities, and spatial arrangements of retained trees.
Windthrow	Wind-caused tree mortality due to toppling or snapping.