Recommendations to Revegetate Riparian Buffers Along Temperature Polluted Streams in the Skagit Basin

Riparian Planting Along Nookachamps Creek March 18, 2021

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Contents

1 Executive Summary

There are 2,208 unforested acres within the one Site-Potential Tree Height (SPTH) buffer along 111.8 miles of temperature polluted salmon streams in the Skagit Basin. To reforest these areas would require eleven years: four years to prepare (including 3.5 years to grow the plants), three years to plant, and five years to maintain the plants. We estimate it would cost $35,227,000. The lead organization(s) would need to employ one part-time executive director, two project managers, one botanist, one field coordinator, fifteen crew leads, and 60 natural resource technicians to complete this work. Local nurseries would need to grow 1,104,000 plants that are at least 18 inches tall. The largest constraints to revegetating these buffer areas would be hiring enough staff and finalizing contracts with landowners.

2 Introduction

This document outlines a strategy to revegetate riparian buffers on temperature polluted salmon streams in the Skagit Basin. It aims to plant these areas within three years, not including preparation and maintenance time. This work is not currently proposed for implementation as regulations do not require it and landowners have not provided permission. But this document identifies the level of effort that would be required if those permissions or regulations were to change in the future.

This strategic road map is based on the experience of the Skagit River System Cooperative habitat restoration program, which has installed 334,000 plants in 580 acres in the last 13 years. Most of the planting areas were in riverine wetlands, active floodplains, and forested uplands and targeted fallow fields that had been cleared for grazing livestock.

3 Study Area

The study focused on unforested areas within the one 200-year SPTH measured from the edge of the active channel on temperature polluted salmon streams in the Skagit Basin. SPTH is defined as the average maximum height of the tallest dominant trees for a given soil classification. We identified impaired streams that support salmon by intersecting the Washington Department of Fish and Wildlife anadromous stream layer for the Skagit watershed (2014) with the Washington Department of Ecology 303d layer (2016) for temperature and dissolved oxygen (Figure 1). We used the Washington Department of Fish and Wildlife's SPTH Map Tool to determine the buffer width (with a 100-foot minimum buffer) along the entire stream, including sections upstream and downstream of the impairments. We excluded tributaries unless they were also impaired. We manually digitized and clipped major paved roadways from the buffer using National Agriculture Imagery Program photography (2017), then removed planted areas based on the Skagit Watershed Council riparian planting database (2018) and Skagit River System Cooperative planting polygons (2021). We removed forested areas from the remaining buffer area using the Washington Department of Fish and Wildlife tree cover layer (2017). Figure 2 shows an area east of Mount Vernon that includes Nookachamps Creek as an example of the mapping methods.

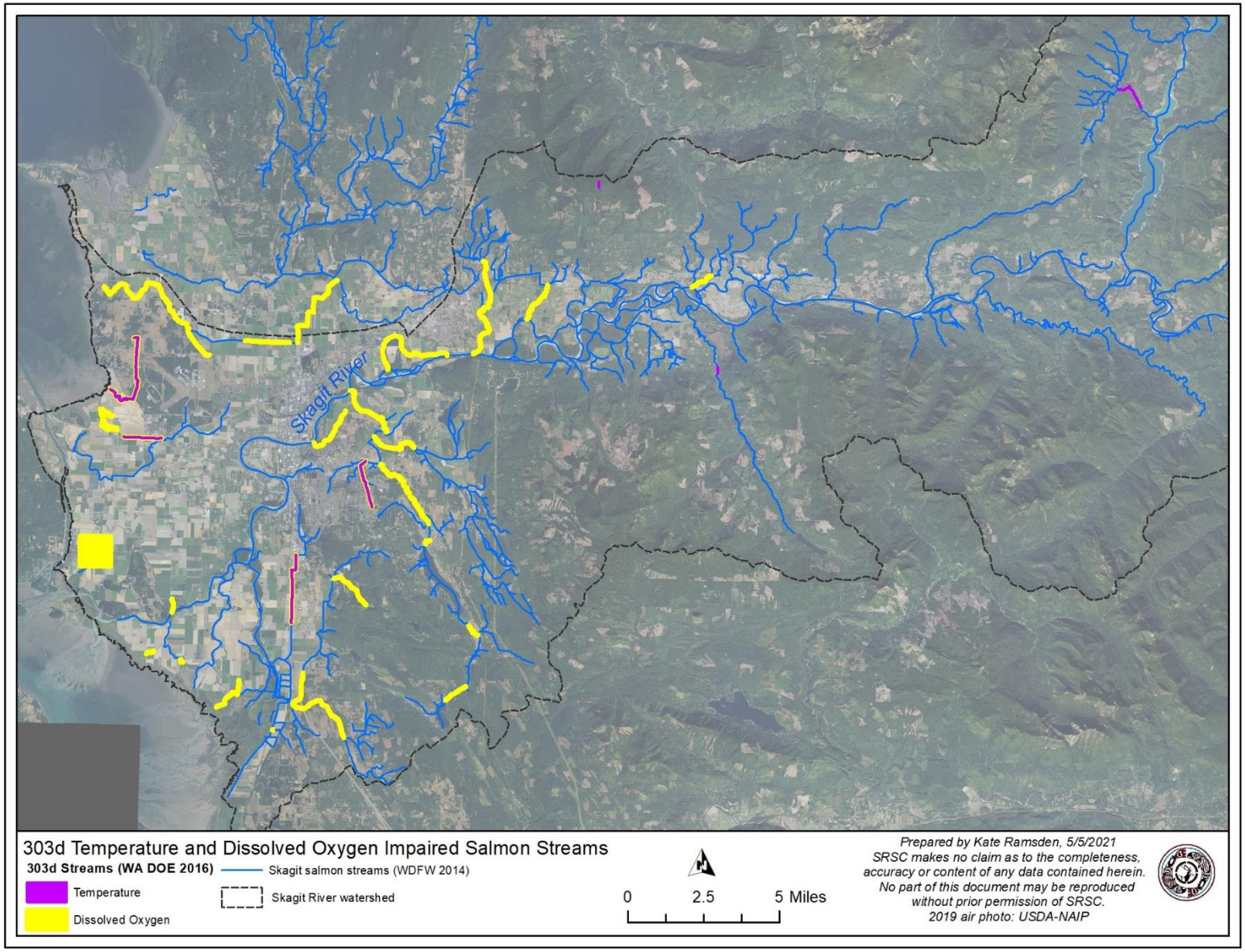

Figure 1. Temperature polluted segments of salmon streams used for this analysis within the Skagit Basin.

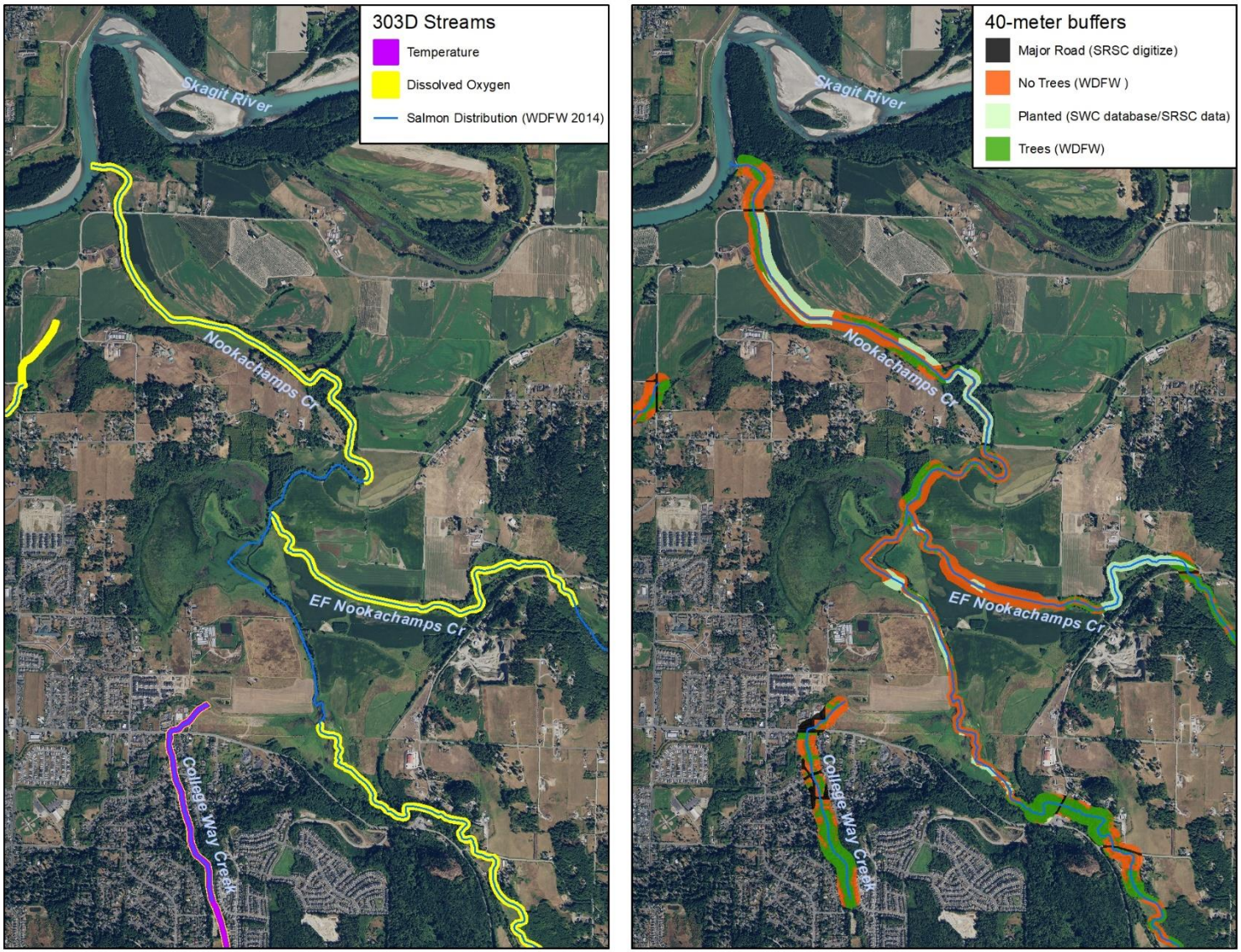

Figure 2. Example of 303d temperature and dissolved oxygen impaired segments (left) and habitat conditions within the one SPTH riparian buffer (right) in an area east of Mount Vernon that includes Nookachamps Creek.

We chose a methodology that could be repeated throughout the Puget Sound, with some caveats. The anadromous stream and 303d layers used USGS National Hydrography Dataset hydrography, which sometimes departed from the stream locations on the aerial photography. We left secondary roads, driveways, houses, and other impervious surfaces unmapped. We did not assess the accuracy of the tree cover dataset.

4 Results

There are 111.8 miles of temperature polluted salmon streams in the Skagit Basin (40.0 miles of 303d temperature and dissolved oxygen impaired segments and 71.8 miles of additional segments up and downstream) with 2,207.9 unforested acres in the one SPTH (835.3 acres along 303d temperature and dissolved oxygen impaired segments and 1,372.6 acres along additional segments up and down stream; Table 1). We identified twenty waterbodies with impaired segments: Bear Creek, Big Ditch/Maddox Creek, Big Indian Slough, Brickyard Creek, Browns Slough, Coal Creek, College Way Creek, Day Creek, East Fork Nookachamps Creek, Fisher Creek, Hansen Creek, Hill Ditch/Carpenter Creek, Joe Leary Slough, Manser Creek, Noname Slough, Nookachamps Creek, Unnamed creek (tributary to Carpenter Creek), Unnamed creek (tributary to Skagit River), Unnamed ditch (tributary to Skagit Bay), and Wiley Slough.

Table 1. Habitat conditions along 303d temperature and dissolved oxygen (DO) polluted streams in the Skagit Basin.

	Unforested (Acres)	Forested (Acres)	Planted (Acres)	Major Roads (Acres)	Total
303d Temperature and DO	835.3	502.3	145.2	99.1	1581.9
Additional Segments Up and Down Stream	1,372.6	1,206.3	49.0	106.1	2734.0
Total	2,207.9	1,708.5	194.3	205.2	4316.0

We omitted the Sauk River from the results. Even though we identified a 1.4-mile-long impaired segment upstream of Darrington, the segment had 95% forest cover in the one SPTH buffer area and including the entire 34-mile-long river seemed disproportionate.

5 Skagit Basin Strategic Road Map

5.1 Lead Organizations

Existing or newly created organizations will need to house and manage the project. Existing organizations that may contain this capacity are the Skagit River System Cooperative, the Skagit Fisheries Enhancement Group, Skagit County, and the Skagit Conservation District.

5.2 Timeline

The timeline to plant 2,208 acres is eleven years (Table 2), including four years to set-up (nurseries need 3.5 years to grow the plants), three years to plant, and five years to maintain the plants. Pre-planting (Years one through four), the lead organization(s) will need to order the plants, hire staff, purchase equipment and vehicles, and finalize landowner contracts and vegetation management plans for the first-year planting areas.

During planting (years five through seven), the lead organization(s) will have to plant and maintain 736 acres per year for three years. The maintenance workload will accumulate as areas are planted. Each year, project managers and botanist will need to finalize new landowner contracts and vegetation management plans for the following year.

Post-planting (years eight through eleven), plant maintenance and invasive species control should continue. The lead organization can start to lay off some staff, reduce hours, and sell unused equipment and vehicles.

5.3 Staff

To complete the work, the lead organization(s) would need to employ one part-time executive director, two project managers, one botanist, one field coordinator, fifteen crew leads, and 60 natural resource technicians. The executive director would direct policy, sign contracts, manage money, and oversee the project managers and botanist. The project managers would develop and negotiate contracts, identify and meet project goals, schedule project tasks, develop budgets, oversee the crew leads and field coordinator, and write progress reports. The botanist would place plant orders, create the vegetation management plans, ensure plant health, and design the as-built documentation. The field coordinator would order supplies, schedule fieldwork, and maintain vehicles and equipment. The crew leads would carry out vegetation management plans and supervise the field crew. The natural resource technicians would plant trees, perform maintenance activities, and treat invasive species.

5.4 Landowner participation

The Washington Department of Ecology could initiate landowner contact as the regulators. The lead organization(s) would follow-up to define the restoration buffer, workout the planting details and work schedule, and sign the contracts. This would require on average two meetings with the landowners. The botanist would meet with the landowner to learn about the site history and receive input on the vegetation management plan.

The landowner contract would include the vegetation management plan and work timeline, list lead organization versus landowner responsibilities, grant land access to the lead organization, and detail the landowner incentives. For example, the Conservation Reserve Enhancement Program incentivizes landowners by leasing the land for at least 15 years.

5.1 Plants

The lead organization would need to contract with local nurseries to grow 1,104,000 plants that are at least eighteen inches tall. The nurseries will need 3.5 years to grow the plants to specifications. The Washington Association of Conservation Districts Plant Material Center in Bow and Fourth Corner Nurseries in Bellingham have the capacity to produce the plants. The work will require bareroot, live stake, and potted stock. Bareroot and live stake stock are less expensive to purchase and transport but potted stock allows the planting season to start in November (bareroot stock is unavailable until mid-December). The extra six weeks would be necessary to meet the project timeline. The ratio of bareroot to potted stock would be seven to three.

Table 2. Timeline to revegetate riparian buffers along temperature polluted salmon streams in the Skagit Basin.

Timing/Task	Year 1 – 4 Pre-Planting	Year 5 Planting + Maintenance	Year 6 Planting + Maintenance	Year 7 Planting + Maintenance	Year 8 – 11 Post-Planting maintenance
Hiring	Hire parttime executive director, 1 project manager, 2 botanists, 15 crew leads, and 60 technicians.	Maintain staff levels.	Maintain staff levels.	Maintain staff levels.	Layoff botanist. Make crew and leads part time.
Equipment	Purchase equipment.	Maintain equipment.	Maintain equipment.	Maintain equipment.	Sell planting equipment; maintain other equipment.
Plants	Contract growers for 1,104,000 plants (331,200 potted and 772,800 bareroot stock).	Pick-up 368,000 plants (110,400 potted and 257,600 bareroot stock).	Pick-up 368,000 plants (110,400 potted and 257,600 bareroot stock).	Pick-up 368,000 plants (110,400 potted and 257,600 bareroot stock).	--
Landowner Interactions	Approach landowners, delineate planting areas, determine planting details, and sign agreements for 736 acres.	Approach landowners, delineate planting areas, determine planting details, and sign agreements for 736 acres.	Approach landowners, delineate planting areas, determine planting details, and sign agreements for 736 acres.	--	--
Planting Plan	Develop vegetation management plans for 736 acres.	Develop vegetation management plans for 736 acres.	Develop vegetation management plans for 736 acres.	--	--
Site Prep	Mow grass and treat invasive species in planting area.	Mow grass and treat invasive species in planting area.	Mow grass and treat invasive species in planting area.	--	--
Planting	--	Plant 736 acres.	Plant 736 acres.	Plant 736 acres.	--
Maintenance	--	Mow around plants, monitor health, replant, and treat weeds on 736 acres.	Mow around plants, monitor health, replant, and treat weeds on 1,472 acres.	Mow around plants, monitor health, replant, and treat weeds on 2,208 acres.	Mow around plants, monitor health, replant, and treat weeds yearly on 2,208 acres.

5.2 Vehicles and Equipment

Vehicles and equipment should be purchased before the start of planting. We estimate the field crew would need thirteen, four-wheel drive, extended cab trucks and the office staff would need three vehicles. We estimate plant installation and maintenance will require fifteen Toro Dingos with 12-inch augers; fifteen Residential Utility Vehicles; twelve 35-horse, John Deere, 4x4 utility tractors with mowing decks; and five 14,000-pound trailers. The project would also require at least fifteen handheld augers and 75 brush cutters.

5.3 Budget

We estimate it would cost $35,227,000 to restore habitat in the riparian buffers along the 112 miles of temperature polluted streams in the Skagit Basin. That includes $6,000 per acre for planting, and $10,000 per acre for 5 years of maintenance. This cost excludes landowner incentives. These programs are outside of our experience, but in 2011, the Conservation Reserve Enhancement Program lease rates were $511.09 per acre per year for fifteen years.

Table 3 includes a rough budget based on our program's average riparian revegetation costs. Vehicle and equipment costs are based on usage allowance rates. Because this is a short-term project, the lead organization(s) would have to sell the vehicles and equipment at the end of the project. For example, the heavy equipment would cost around $1,240,000 to purchase and $370,000 to maintain. At the end of the project, $612,100 (49 percent of purchase price) would have to be recuperated to stay within the budget.

Table 3. Estimate budget to revegetate 1,898 acres based on average Skagit River System Cooperative project costs.

Salaries, Wages, and Benefits	$21,986,700.00
Vehicle Purchase and Maintenance	$997,900.00
Supplies and Services	$4,061,500.00
Equipment Purchase and Maintenance	$907,700.00
Overhead	$7,273,200.00
Total Projected Expenditures	**$35,227,000.00**

5.4 Constraints and Challenges

One constraint would be hiring enough technicians and crew leads. To account for this, we increased technician's wages from $17.50 to $21.00 per hour in the budget. The availability of housing in the area may become an issue if a lot of people come from out of town. If hiring numbers are inadequate, the lead organization(s) could contract crews from the Earth Corps or Washington Conservation Corps. These organizations will require one year notice and their education-focused crews have been less productive than our crews in the past. Low productivity would delay the timeline and increase costs.

Another constraint would be finalizing the contracts on private lands. Even with landowner incentives and new regulations, fastidious landowners could set back the timeline.

6 Best Practices

6.1 Vegetation Management Plan

Each planting site should receive a detailed vegetation management plan that details planting, maintenance, and invasive species control methods. The botanist will need to identify the ecology of each site and use historical photos and landowner knowledge to learn its history. Soil compaction, overgrazing,

and over cultivation may affect planting and the plan should include corrective measures such as scarification, high-grow tilling, and soil amelioration.

Hydrology, soils, and available sunlight determine the appropriate planting species. The botanist can determine hydrology by using the wetland indicator status of species growing on the site, the proximity of the planting area to water, the soil saturation depth at varying times of year, and Skagit County well water level data. Areas that are frequently flooded may not support coniferous tree species.

The U.S. Department of Agriculture soil map for Skagit County can provide an overview of soils at the site. The botanist should also test the soils in the field by digging 22-inch-deep sample pits. Figure 3 and Table 4 show field soil samples and the U.S. Department of Agriculture soil map at a planting site on Gravel Creek near Darrington. The U.S. Department of Agriculture maps the entire planting area as Giles Variant silt loam, but the field test additionally identified areas of sand, sandy loam, and fine loamy sand. Loams provide the best structure for establishing native plants. Clay soils can be too fine to establish conifers. Trees planted in sandy soils may have low survivorship without the topdressing of mulch to hold moisture.

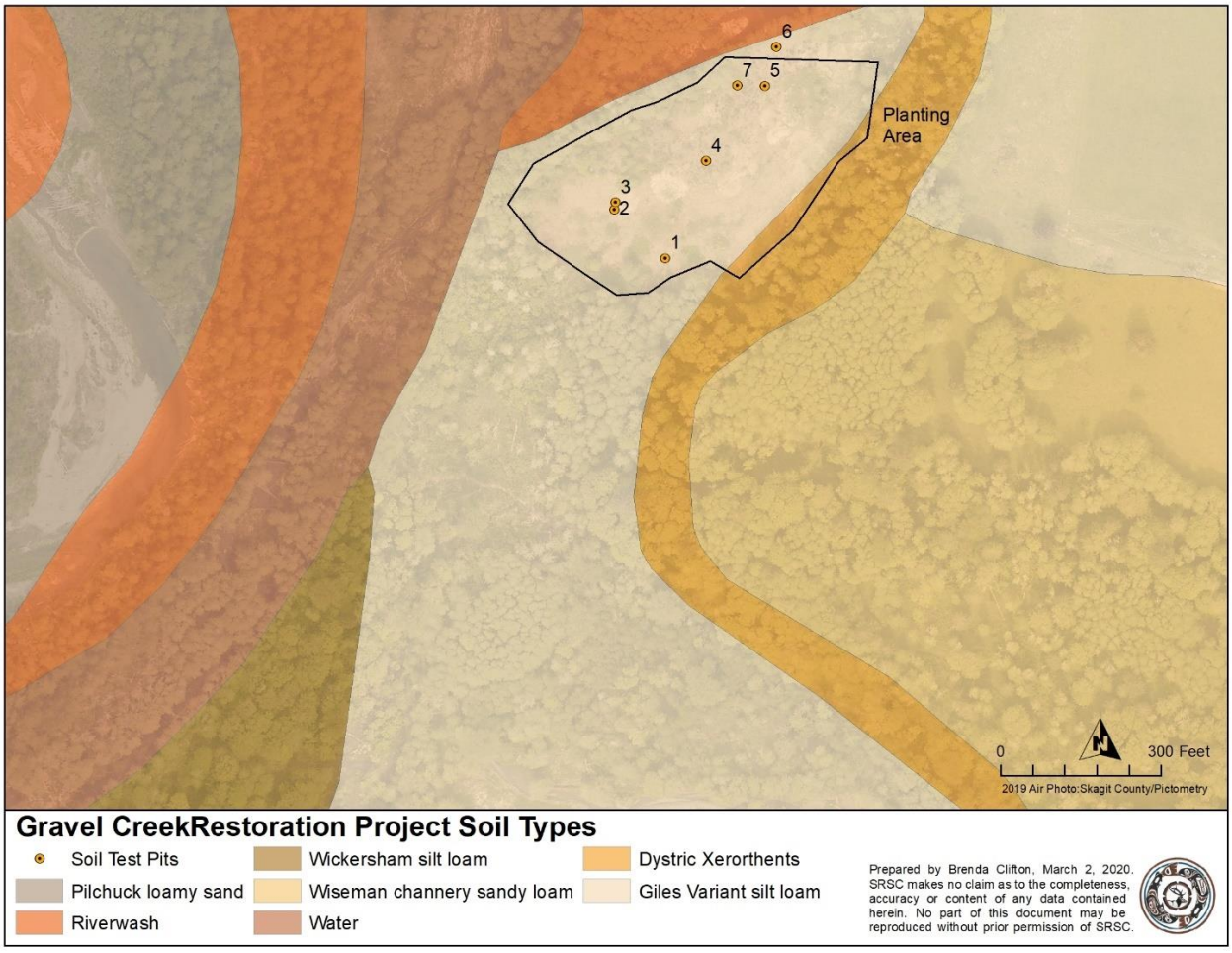

Figure 3. U.S. Department of Agriculture soil map and sample pit locations at the Gravel Creek planting site.

Table 4. Soil textures encountered in the Gravel Creek planting area.

Pit	A Horizon Texture	B Horizon Texture	Vegetation Description
1	Silt loam	Silt loam	Healthy; diverse species composition
2	Silt loam	Silt loam	Healthy; diverse species composition
3	Silt loam	Silt loam	Healthy; diverse species composition
4	Fine sandy loam	Sand	Dead; grass and scotch broom
5	Sandy loam	Fine sandy loam	Healthy; diverse species composition
6	Fine sandy loam	Loamy sand	Healthy; diverse species composition
7	Silt loam	Silt loam	Healthy; diverse species composition

6.2 Schedule

Planting, maintenance, and invasive species control occur throughout the year (Table 5). May can be a difficult month because it is too dry to plant, but too early to mow around trees (the grass will grow back). We fill this month by planting wetland areas, mowing reed canarygrass (the first of two mowings), or beginning invasive species treatment (triclopyr herbicide is effective year-round). Bad weather often prevents planting in January.

Table 5. Timing of planting, maintenance, and invasive species management tasks throughout the year.

Action	Task	Timing
Site Preparation	Mow weeds to spray	June
	Mow existing grass and spray weeds	August - October
	Seed bare areas with grass	September - October
Planting	Install stakes	November - February
	Install potted stock	November - April
	Install bareroot stock	December - April
Maintenance	Release plants	June - July
Invasive Species Control	Spray herbaceous weeds (thistle, tansy, etc.)	July
	Spray shrub and vine weeds (Scotch broom, blackberry, etc.)	August - October
	Spray reed canarygrass around plants	August - October
	Spray knotweed	August - October

6.3 Site prep

Bare soil areas should be seeded with a low growing grass mixture to prevent invasive species from colonizing the site. We use 25 percent creeping red fescue, 23 percent annual ryegrass, 12 percent perennial ryegrass, 20 percent Kentucky bluegrass, and 20 percent alsike clover in our mix. Areas with tall grass should be mowed before planting. Areas with dense weed cover should be mowed and sprayed with herbicide before planting. Fencing may be needed to exclude cattle or beavers from the planting area.

6.4 Species

The Skagit River System Cooperative habitat restoration plantings consist of 70 to 80 percent conifers (soil and hydrology permitting). Conifers provide more shade, live longer, and breakdown more slowly in water (for large-woody debris) than deciduous species. Individual species should be selected based on current site conditions (Table 6). Additional selection criteria could include benefits to wildlife. Planting plans should include as many species as possible to increase species richness and diversity. Special care should be taken to install each species into the appropriate microsite.

Species	Scientific Name	Habit	Moisture Tolerance	Light Tolerance	Soil texture Tolerance	Anaerobic Tolerance	Drought Tolerance
Cedar, Western Red	*Thuja plicata*	Conifer	Wet-moist	Full shade to full sun	Medium	None	Low
Douglas Fir	*Pseudotsuga menziesii*	Conifer	Medium-dry	Full sun	Medium-coarse	Low	Low
Fir, Grand	*Abies grandis*	Conifer	Moist-dry	Full shade to full sun	Med-Coarse	Low	Medium
Hemlock, Western	*Tsuga heterophylla*	Conifer	Moist-dry	Full shade	Medium	None	Low
Pine, Shore	*Pinus contorta var. contorta*	Conifer	Wet-xeric	Partial shade-full sun	Fine-coarse	Low	Medium
Pine, Western White	*Pinus monticola*	Conifer	Moist-dry	Partial shade-full sun	Medium-coarse	None	Low
Spruce, Sitka	*Picea sitchensis*	Conifer	Wet-moist	Partial shade-full sun	Medium-coarse	Low	Low
Alder, Red	*Alnus rubra*	Tree	Wet-dry	Partial shade-full sun	Fine-coarse	Low	Medium
Cascara	*Rhamnus purshiana*	Tree	Moist-dry	Partial shade	Medium-coarse	None	Medium
Cherry, Bitter	*Prunus emarginata*	Tree	Moist-dry	Partial shade-full sun	Coarse	None	Medium
Cottonwood, Black	*Populus balsamifera* ssp. *trichocarpa*	Tree	Moist-medium	Partial shade-full sun	Fine-coarse	Medium	Low
Crabapple, Pacific	*Malus fusca*	Tree	Wet-moist	Partial shade-full sun	Medium-coarse	Fine-medium	Low
Hawthorn, Douglas	*Crataegus douglasii*	Tree	Wet-medium	Partial shade-full sun	Fine-coarse	Medium	Medium
Madrone, Pacific	*Arbutus menziesii*	Tree	Xeric-dry	Full sun	Med-Coarse	Low	High
Maple, Big Leaf	*Acer macrophylla*	Tree	Medium-dry	Full sun	Fine-coarse	Medium	Low
Maple, Vine	*Acer circinatum*	Tree	Moist-medium	Partial -full shade	Fine-coarse	None	Low
Paper Birch	*Betula papyrifera*	Tree	Wet-moist	Partial shade	Fine-medium	Low	Low
Willow, Pacific	*Salix lucida* ssp. *lasiandra*	Tree	Wet-moist	Partial-full sun	Fine-coarse	High	Low
Currant, Red Flowering	*Ribes sanguineum*	Shrub	Medium-dry	Partial shade-full sun	Medium-coarse	None	Medium
Dogwood, Pacific	*Cornus nuttallii*	Shrub	Moist-dry	partial-full shade	Fine-medium	Low	Low
Dogwood, Red Osier	*Cornus sericea*	Shrub	Wet-moist	Partial shade	Fine-coarse	High	Low
Hardhack	*Spiraea douglasii*	Shrub	Moist-medium	Partial shade	Medium-coarse	High	Medium
Hazelnut, Beaked	*Corylus cornuta*	Shrub	Medium-dry	Partial shade-full sun	Medium-coarse	Low	Low
Indian plum	*Oemelaria cerasiformis*	Shrub	Medium-dry	Partial shade	Fine-coarse	Medium	Low
Mock Orange	*Philadelphus lewisii*	Shrub	Moist-medium	Partial shade	Medium-coarse	Medium	Low
Ninebark, Pacific	*Physocarpus capitatus*	Shrub	Medium-dry	Partial shade	Medium-coarse	None	Low
Oceanspray	*Holodiscus discolor*	Shrub	Medium-dry	Partial shade-full sun	Fine-coarse	Medium	Low
Oregon grape, tall	*Mahonia aquifolium*	Shrub	Moist-dry	partial-full shade	Medium-coarse	None	High
Rose, Baldhip	*Rosa gymnocarpa*	Shrub	Medium-dry	Partial shade	Fine-coarse	Low	Low
Rose, Clustered wild	*Rosa pisocarpa*	Shrub	Wet-dry?	Full sun	Fine-coarse	Medium	Medium
Rose, Nootka	*Rosa nutkana*	Shrub	Moist-dry	Partial shade-full sun	Fine-coarse	High	Medium
Salal	*Gaultheria shallon*	Shrub	Medium-dry	Partial shade-full sun	Medium-coarse	Low	Medium
Salmonberry	*Rubus spectabilis*	Shrub	Moist-medium	Partial -full shade	Medium-coarse	High	Medium
Serviceberry	*Amelanchier alnifolia*	Shrub	Medium-dry	Partial shade	Fine-coarse	None	Low
Snowberry, common	*Symphoricarpos albus*	Shrub	Moist-dry	Partial shade-full sun	Fine-coarse	Low	High
Thimbleberry	*Rubus parviflorus*	Shrub	Moist-xeric	Partial shade	Fine-medium	Low	Medium
Twinberry	*Lonicera involucrata*	Shrub	Wet-medium	Partial shade-full sun	Fine-medium	High	Low
Willow, Hooker	*Salix hookeriana*	Shrub	Wet	Full sun	Fine-coarse	High	None
Willow, Scouler's	*Salix scouleriana*	Shrub	Wet-moist	Partial shade-full sun	Fine-coarse	Medium	Medium
Willow, Sitka	*Salix sitchensis*	Shrub	Moist-medium	Partial-full sun	Fine-coarse	Low	Medium

6.5 Planting Methods

Planting should occur from November to April. Plants should be installed at nine foot-on-center-spacing (500 plants per acre). A three-foot diameter hole should be cleared of vegetation at each planting site using a brush cutter. Bareroot and potted plants should be placed in a twelve-inch-wide hole that is slightly deeper than the roots. The plants should then be surrounded by soil. Planting should avoid air pockets and J-roots.

The plantings need to be maintained for at least five years. Maintenance includes mowing competing vegetation around each plant at least once in early summer, with additional herbicide application as needed to control invasive species. The botanists should monitor plantings on a regular basis to ensure health and acceptable survivorship. Maintenance plans should address any identified issues. Low survivorship areas should be replanted with consideration to the cause of mortality.

6.6 Herbivory prevention

Previous open area planting projects in the Skagit River watershed have shown excessive damage by vole populations. Biodegradable mesh tubing should be used to protect the plants. These should be buried approximately 1.5-feet into the ground to prevent removal by elk.

In sites frequented by the North Cascade (Nooksack) elk herd, all western red cedar should be companion planted with Sitka spruce to reduce herbivory. Deciduous species should be treated twice a year with Plantskydd elk repellant. A study in a middle Skagit riparian planting showed an 80 percent reduction of elk browse on cedars planted with spruce or treated with repellant compared to the control.

The field crew may need to install fencing in areas with beaver activity. The fence should be constructed parallel to the stream, as close to the water as possible without undue risk of obstructing flow (generally at the top of the streambank). Fences should be constructed from 14.5-gauge Woven Wire Field Fencing that is 47-inches high. T-posts should be driven 24 inches in the ground, no more than 10-feet apart. H-brace assemblies at the ends and corners should be made from five-inch diameter treated wood posts. Field fencing should be buried eight to twelve inches in the ground, or 12 inches folded toward the stream at ground level and secured with rebar stakes. At each end, an extension to the fencing should run to the outer edge of the planting area perpendicular to the stream.

6.7 Monitoring

Five years after installation, the botanist should measure survivorship in permanent plots that encompass ten percent of the planted area. The stocking goal is 190 trees per acre (based on recommendation of WAC 222-34-010 Required Reforestation—West of Cascades Summit) or 38 percent survivorship.

6.8 Invasive Species Control

Integrated Pest Management is the preferred approach at the site. It uses prevention, active treatment, and long-term planning to achieve maximum control with minimal environmental impacts. Preventive measures avoid the spread of existing populations to new areas. Examples include grass seeding exposed soil and monitoring for new invasions. Active treatment includes mechanical and chemical control: pulling, trimming with weed whackers, mowing with a tractor, and herbicide application. All foliar chemical

treatments incorporate the use of Agridex surfactant and Hi-Lite blue dye. The long-term strategy should be to shade-out invasive species with planted tree cover.

Botanists should map out targeted weeds on the site and develop invasive species management plans. Due to funding limitations, control actions should target Washington State Class A and B Noxious Weeds, and species that could out compete planted trees, such as blackberry.

Herbicides should be used sparingly and only when they are the best control option. Crew leaders must be licensed through the Washington Department of Agriculture and herbicides must be applied according to label instructions.

6.8.1 Herbicide Options

Aminopyralid (Milestone®)

Aminopyralid works by mimicking auxins. It enters treated vegetation through the leaves and roots, and replaces natural auxins at binding sites, causing abnormal growth patterns. and disrupting the growth processes of the plant.

Example target weeds: Canada thistle (*Cirsium arvense*) and tansy ragwort (*Jacobaea vulgaris*).

Advantages: It can nearly eliminate Asters, like Canada thistle, from a site in a single application. It is a selective herbicide that does not kill grasses and is not damaging to conifers. The signal word “caution” on the label means that the product is only slightly toxic to the applicator.

Disadvantages: It can be persistent in soils and it is not approved by the Washington Department of Ecology for aquatic applications.

Tryclopyr choline (Vastlan®)

Tryclopyr mimics plant growth hormones called auxins, interfering with the normal plant growth response. It is readily absorbed through both roots and leaves and translocates throughout the plant. It is especially effective on controlling woody weeds and vines.

Example target weeds: Himalayan blackberry (*Rubus armeniacus*), old man’s beard (*clematis vitalba*), and Scotch broom (*Cytisus scoparius*).

Benefits: It is approved for use in riparian areas. It is a selective herbicide that does not kill grasses, therefore reducing the germination and establishment opportunities for new weeds. It is also not damaging to selected conifers before bud break and in fall applications.

Disadvantages: Signal word “warning” on label means that the product is slightly caustic.

Glyphosate Isopropylamine Salt (AquaMaster®)

Glyphosate based herbicides inhibit an enzyme involved in the synthesis of the aromatic amino acids: tyrosine, tryptophan and phenylalanine. It is absorbed through foliage and translocated to growing points and is only effective on actively growing plants.

Example target weed: Reed canarygrass (*Phalaris arundinaceae*).

Benefits: It degrades quickly and is Washington Department of Ecology approved for aquatic applications. Signal word "caution" on label means that the product is only slightly toxic to the applicator.

Disadvantages: It is a non-selective herbicide that kills pasture grass and creates germination and establishment opportunities for new weeds.

Imazapyr (Habitat®)

Imazapyr inhibits branched side-chain amino acid Cyanamid synthesis; it binds to and deactivates the enzyme Acetolactate Synthase.

Example target weed: Knotweed.

Benefit: Washington Department of Ecology approved for aquatic applications. Only herbicide found to be effective at controlling knotweed. Signal word "caution" on label means that the product is only slightly toxic to applicators.

Disadvantages: Can be persistent in soils.

6.8.2 Control Recommendations for Common Species

Blackberry

Blackberry is a Washington State Class C Noxious Weed. Its control is not required in Skagit County; however, it will quickly outcompete the plantings if left unchecked. Blackberries reproduce vegetatively by root and stem fragments; daughter plants can form wherever canes touch the ground. Plants begin flowering in spring with fruit ripening in early August. Seeds can remain viable in the soil for several years. As a treatment option, digging up the roots with a tractor can be effective at removing most established plants. However, soil disturbance can produce opportunities for new weed infestations. Also, any root fragments left in the soil can re-sprout. Mowing is an effective way to remove biomass and deplete root sugar reserves. However, mowing will not kill the entire plant. Herbicides are effective at killing the entire plant; but it can be hard to reach the middle of large patches. For effective control, we recommend technicians mow large populations in June, then spot spraying sprouts in September to October.

Butterfly Bush

Butterfly bush (*Buddleia davidii*) produces copious amounts of lightweight seeds that are dispersed by wind and water; a single flower produces up to 40,000 seeds. The seeds remain viable for three to five years. Butterfly bush also develops adventitious roots on branches, which should not be left on the bare ground, and resprouts from cut rootstock. Although mowing costs the plant energy, the stumps readily sprout and flower. Small seedlings can be easily pulled, but adults require herbicide application. For effective control, we recommend technicians treat butterfly bush with a mixture of mowing, pulling and applying pure triclopyr to cut stumps.

Canada Thistle

Canada thistle grows extensive rhizomes; single plants cover large areas with many stems. It flowers from June to September. Seeds develop eight to ten days after the flowers open. One-quarter inch of root stores enough energy to develop new plants and survive for one-hundred days without above-ground shoots. Digging-up plants is impractical because roots can grow six feet deep. Mowing is ineffective as plants resprout and flower. Therefore, herbicide application is the only viable control option. For effective control, we recommend technicians treat Canada thistle with triclopyr or aminopyralid in July.

Knotweed

Knotweed (*Polygonum* sp.) is a Class B Noxious Weed with mandatory control in Skagit County. Knotweed forms dense stands that crowd out all other vegetation, degrading native plant and animal habitat. Vigorous rhizomes form a deep, dense mat. Knotweed reproduces both by seed and asexually from rhizomes and roots. Root fragments, as small as ½ inch can form new plants. Cut or broken stems will sprout if left on moist soil or put directly into water. Knotweed treatment options are limited. Mowing and manual removal ineffective. Covering the patch with geotextile fabric is effective but cost inefficient for large areas. A 1percent imazapyr solution is the most effective chemical treatment. For effective control, we recommend technicians bend canes in July, to reduce the plant's height, then treat with imazapyr in August to September.

Morning glory

Morning glory (*Convolvulus arvensis*) reproduces vegetatively from fragmented roots, rhizomes and stems and sexually by seeds that can lie dormant for up to 20 years. Flowers develop from May until the first frost. Tilling is ineffective because root or rhizome fragments resprout; mowing is also incapable of controlling this plant. Repeated pulling works, but it is labor intensive. Herbicides control morning glory, when reapplied for several growing seasons. For effective control, we recommend technicians spray with triclopyr in July and again in September.

Old Man's Beard

Old man's beard is a Washington State Class C Noxious Weed, without mandatory control in Skagit County. However, it is fast growing, and the vines could smother the planted trees. It produces up to 100,000 seeds per plant that remain viable for up to five years. It can also spread by vegetative fragments rooting at the nodes. Mowing alone is not an effective control method since cutting can stimulate plant growth and spread vegetative propagules. Herbicide may not reach tall vines and may subject non-target plants to spray. For effective control, we recommend technicians mow old man's beard in early summer, and then spray sprouts with triclopyr, before seeds form.

Policeman's Helmet

Policeman's helmet (*Impatiens glandulifera*) is a Washington State Class B Noxious Weed with mandatory control in Skagit County. Policeman's helmet mainly reproduces by seed, but it can also spread vegetatively. It is an annual plant that flowers from July until September. A single plant can produce up to 2500 seeds that are viable for 18 months. Policeman's helmet has shallow roots is easily pulled. Mowing is also effective and less disturbing than hand-pulling. Herbicide use is necessary for very large infestations. For effective control, we recommend technicians mow in June, followed up by hand pulling or additional mowing in July or August.

Reed Canarygrass

Reed canarygrass is a Washington State Class C Noxious Weed with no control required in Skagit County. However, stems can grow up to 9 feet tall and outcompete planted trees. Reed canarygrass spreads by seeds and vegetatively by rhizomes. Mowing reduces populations by preventing seeds from forming and reducing the plant's competitive advantage. This allows surrounding vegetation to move in, although it is unlikely to kill the grass. Treatment with glyphosate will control reed canarygrass, but several years of treatment is needed. The long-term strategy is to shade-out the grass with planted trees. If reed canarygrass populations are in upland areas, we recommend spraying around plants with glyphosate in September and mowing in June or mowing once in May and again in June. If populations are in wetland areas, we recommend dense willow plantings. Six-foot long live stakes should be installed at a density of 5000 plants per acre (3-foot-on-center spacing). This method requires no maintenance, the height and depth of the stakes allows the willows to outcompete reed canarygrass for light and water.

Scotch broom

Scotch broom is a Washington State Class B Noxious Weed with mandatory control in Skagit County. It reproduces primarily by seed. Flowers bloom from April to June and seeds mature in late summer. A single plant can produce over 10,000 seeds per year, which can survive in the soil for up to 60 years. Pulling, mowing (older plants), and herbicide application are effective treatment methods. For effective control, we recommend technicians combination of pulling, mowing and spraying. Large plants should be mowed in the summer. Smaller plants can be pulled at any time of year. Remaining plants should be treated with triclopyr in September to October.

Sulphur Cinquefoil

Sulphur cinquefoil (*Potentilla recta*) flowers from early June through July with seeds forming in mid to late July. Plants reproduce by seed or stems that contact the ground and produce roots at the nodes. Mowing is ineffective as plants produce new shoots from the rootstock. Seeds can survive for four or more years in the soil. Field crews can dig up plants in the spring or early summer before the seeds mature; however, the roots are deep and extensive. For effective control, we recommend technicians spray the plants with aminopyralid or triclopyr in early summer before the seeds begin to form.

Tansy Ragwort

Tansy ragwort flowers in June. Each plant forms up to 150,000 seeds that remain viable for five years. Mowing is ineffective as plants re-sprout and flower. But plants can be pulled after they bolt, but before they flower. Herbicide should be applied when the flower is in the early bud stage. For effective control, we recommend treat plants with triclopyr or aminopyralid in July.