# Invasive Plant Management Project

For The Northern Tongass

## Soil and Wetlands Report

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for:

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# Contents

# Introduction

This report provides soil and wetland resource information for the environmental analysis of the potential effects associated with implementing manual, mechanical and chemical invasive plant treatments.

## Current Management Direction

Applicable Federal, State and municipal laws, regulations, policies which govern the management of soils and wetlands include:

- Tongass Land and Resource Management Plan
- Forest Service Manual (FSM) 2554
- Forest Service Soil and Water Conservation Handbook (FSH 2509.22)
- National Core BMP Technical Guide
- Executive Order 11990 Protection of Wetlands
- 40 Code of Federal Regulations (CFR) 230 Section 404
- 33 CFR 323.3(b) requiring federal agencies to apply for a permit for discharge/fill in a wetland.
- 33CFR 320.4(b) (Directs federal agencies to follow EO 11990)
- The Clean Water Act Section 404b
- US Corps of Engineers Wetlands Delineation Manual (1987) and Alaska revision 2006

## Proposed Activities

The Proposed Activities would treat terrestrial and aquatic invasive plants using integrated methods including chemical (herbicides and adjuvants) and physical treatments (mechanical and manual treatment). Ground based herbicide application methods would be used based on site accessibility, topography, and the size of treatment areas. No aerial treatment is proposed. Broadcast, spot and selective hand spraying (using backpack) where individual and groups of plants are targeted would be the methods of application. Broadcast spraying differ from spot and selective spraying in that the target area of application is typically greater than one acre in size and the herbicide is applied to cover an area of ground rather than individual plants. This method is used when the weed is dense enough that it is difficult to discern individual plants and the area to be treated makes spot spraying impractical.

The proposed project area consists of all terrestrial lands within the four norther Ranger Districts and one National Monument on the Tongass National Forest including State lands, Native corporation lands, private, and municipal landownerships. Some aquatic sites will also be included in this landscape; however infested aquatic sites are rare and comprise very small areas of infestation.

## Overview of Issues Addressed

Invasive plants provide ground cover that could be disturbed by treatments. Herbicide use may affect soil organisms or soil biology. The existence of invasive plants also can negatively affect soils. Effects are based on soil disturbance levels, soil types and the properties of individual herbicides.

*Issue Measures:*

- Potential for soil disturbance from manual or mechanical treatments resulting in losses to site quality and/or site productivity;
- Potential for toxicity to microbes from herbicides and resulting effects to soil productivity;
- Potential for soil erosion from treatment methods; and
- Potential for herbicide to enter stream (both above and below-ground) systems or other aquatic sites.

# Affected Environment

## Existing Condition

A wide variety of soil types occur in the project area. They have developed in a cool, moist, maritime climate. Soils range from moderately deep, well-drained mineral soils that support productive forests to very poorly-drained organic soils that support non-forested wetland vegetation. Most soils in the project area are covered with an organic mat or duff layer four to eight inches thick. The buildup of organic material on the mineral surfaces is a result of the cool and moist, high precipitation prevalent in the maritime climate of Southeast Alaska. The high precipitation and cool temperatures result in the accumulation of organic material in surface horizons to the degree that organic soils are commonly formed in areas with poor drainage. Soil texture, including organic matter content, plays a significant role in the affects analysis for this project. Soil texture is the proportion of sand, silt and clay, including coarse materials such as gravel, boulders and rocks. The soil textures also include organic matter content, both as an organic duff layer (where it overlies the mineral soils) as well as that portion of the soil profile that has both illuvial (accumulated from layers above) and in situ organic materials (e.g. organic soils called Histosols). In general, coarse-textured soils contain high amounts of sand and coarse fragments, called gravel, boulder or rock.

Coarse textured soils are commonly found in alluvial areas and in deposits of glacial till throughout the project area. They may also be common on steep slopes that are actively moving downslope as a function of gravity (i.e. colluvium). Site types which have coarse-textured soils include roads, trails, rock quarries, some recreation sites and estuaries (a subset of the wetland site type). Streams may also have coarse-textured soils, but this will vary depending on the channel type. Alluvial fans and floodplains channel types will have the coarsest soil textures.

All other site types typically contain loamy soils which contain higher proportion of silt, clay and organic matter then the coarse textured soils, as well as thicker organic duff layers on the soil surface. These soils are most frequently found in the following site types: administrative sites, campgrounds, cabins, forests, and some stream channels. Wetlands typically contain organic soils and are more fully described in the section below.

In Southeast Alaska, site productivity is primarily a function of soil drainage and soil depth. Soil drainage refers to the frequency and duration of periods of saturation or partial saturation and is categorized into four classes, from well-drained to very poorly-drained. Well drained soils tend to support highly productive forested ecosystems (higher volume timber stands) while poorly drained soils support highly diverse forested ecosystems, yet lower volume timber stands and other shrub or herbaceous vegetation types. Typically, soils that are poorly drained will meet the criteria of a wetland.

Soils that support invasive species have generally been physically altered by disturbance activities creating conditions much different from our natural soils. These activities include road construction, trail construction or maintenance, timber harvest where soils have been scraped or otherwise disturbed, quarry excavation, or impacts from recreational uses (e.g. trampling). Disturbed soils typically lack surface organic layers, are compacted, and may be covered by shot rock or similar gravel-like material. These disturbed soils contain high amounts of gravel and lack the high nitrogen content derived from organic layers, thus support species that are typically early successional (e.g. pioneer species), which include many of our known invasive plants. In general invasive plants occur where humans have had influence on the landscape.

Disturbed soils which occupy quarries, roads, or constructed trails can also be manipulated in ways that are different from natural soils. In quarries, soils may be moved to the side and piled; the quarry itself is composed of rock or coarse gravel. Roads typically have coarse “shot” rock substratum and may be capped with smaller rock or asphalt. Trails are typically constructed of gravel or native soil tread which lack a surface duff layer and may be compacted or puddled. All of these conditions are conducive to the establishment of invasive plants.

## *Impacts of Invasive Plants on Soils and Wetlands*

There are currently approximately 1430 acres of infestation on all lands in the project area. The impacts invasive plants have on soils and subsequent impacts on soil properties as a result of treatment methods are described as follows: 1) impacts on site productivity as a function of changes in soil microorganisms; and 2) impacts to soil quality as a function of vegetation cover removal leading to surface erosion and other physical disturbances.

### Soil Quality

Invasive plants can affect soil quality due to changes in the natural nutrient input caused by invasive plant infestations. Invasive plants have the ability to out-compete native species for water and nutrients from the soil (Weidenhamer and Callaway, 2010). Total vegetative cover may be reduced on invasive plant-infested sites and can result in higher evaportranspiration rates from exposed soil. Reduced cover means increased sunlight and warming of the soil, which can affect the soil microbial population. Infested sites have been shown to negatively affect mycorrhizal root colonies (Sylvia and Jarstfer, 1997).

Soils infested with invasive plants have been shown to be more susceptible to erosion than soil supporting native grasses (Lacey et al., 1989). Invasive plants are less able to dissipate the energy of rainfall, overland flow, and wind that may cause soil erosion primarily due to the loss of cover provided by native plants on site.

Region 10 Soil Quality Standards (SQS) state that a minimum of 85 percent of an area should be left in a condition of acceptable productivity potential for trees and other managed vegetation following land-management activities (FSM 2554). Detrimental soil areas are areas of soil that have been altered to the point where soil productivity has been affected by erosion, compaction, puddling, and removal of organic layers and/or mixing-churning as a result of disturbance. They are typically associated with road construction, log felling, and log yarding, however site quality could also be affected by loss of soil organisms that contribute to productivity. Maintaining vegetation cover over all soil is the primary way to avoid loss of site quality and maintain overall soil productivity.

## Soil Erosion

Soil erosion occurs naturally in the form of mass movement events such as landslides in the mountainous terrain and fluvial action along river systems. Dense vegetative cover protects much of the native soils from surface erosion, thus when the vegetation is removed erosion can occur. The amount of erosion depends on the erodibility of the soil, the amount and intensity of rainfall, slope length and slope steepness. Maintaining a soil duff layer and vegetative cover is the primary means of preventing soil erosion and sedimentation.

## Soil Productivity

Invasive plants are often able to out-compete native vegetation. Certain invasive plants exhibit allelopathy which results in conditions similar to reduced productivity. Allopathic plants are able to produce compounds which deter other plants from growing in the surrounding area, resulting in less competition for available resources. Examples of allelopathic invasive plants known on the Tongass include, orange hawkweed, Canada thistle and spotted knapweed. A literature search for impacts to soil biota from allopathic compounds was conducted for this report; however no information was found.

## Wetlands (Including Estuaries)

The Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USCOE) jointly define wetlands as: "those areas that are inundated or saturated by surface or groundwater with a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas".

Wetlands are valued for their physical, chemical and biological functions. Physical functions include flood conveyance, surface and ground water regulation, sediment retention and temperature moderation. Chemical functions include nutrient storage, pH moderation and carbon storage. Biological function include habitat for terrestrial, aquatic and marine plants and animals.

Wetlands make up about 18 percent of the project area.

### *Wetland Types in the project area*

The northern end of the Tongass National Forest has several different types of wetlands (Table 1). The wetland classification is hierarchical with its broadest level divided into 5 major wetland systems: marine, estuarine, riverine, lacustrine, and palustrine (Cowardin et al., 1979). Only intertidal and terrestrial wetlands (estuarine, riverine, lacustrine, and palustrine) will be discussed. Intertidal estuarine wetlands are generally those in the intertidal zone that have a brackish component (part salt water, part fresh water). Riverine wetlands include wetland found within fresh water rivers and stream channels. Lacustrine wetland are defined as those wetlands and deepwater habitats within lakes deeper than 2 meters and larger than 20 acres in size. Palustrine ponds were added to the lacustrine wetlands calculation because they are similar habitat. Palustrine wetlands are generally known as marshes, bogs, muskegs, fens, and forested wetlands.

**Table 1. Wetland acres and proportion of project area**

| Wetland Systems and Subsystems | Wetland Acres | % Project Area | % Wetlands |
|---|---|---|---|
| Estuarine Intertidal | 37,008 | 0% | 2% |
| Lacustrine[1] | 113,970 | 1% | 8% |
| Marine[2] | 15,006 | 0% | 1% |
| Palustrine (Total) | 1,303,016 | 16% | 86% |
| Emergent | 364,728 | 4% | 24% |
| Forested | 638,458 | 8% | 42% |
| Moss-lichen | 1,838 | <<1% | <1% |
| Scrub-shrub | 279,610 | 3% | 19% |
| Riverine | 38,722 | 0.5% | 3% |
| Total Wetland | 1,507,723 | 18% | -- |
| Project Area Size | 8,197,031 | -- | -- |

1. Includes Palustrine Ponds
2. Includes subtidal estuarine wetlands.

### Estuarine

Estuarine wetlands include tidal wetlands adjacent to deepwater marine habitats that are generally semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by fresh water runoff from the land. The estuarine system includes estuaries and lagoons. Estuarine water regimes and water chemistry are affected by oceanic tides, precipitation, and freshwater runoff from land areas, evaporation and wind. The intertidal subsystem of estuaries is exposed and flooded by tides, and includes the associated splash zone. Estuarine intertidal subsystems are subdivided into several classes: rock bottom, unconsolidated bottom, aquatic bed, reef, streambed, rocky shore, unconsolidated shore, emergent wetland, scrub-shrub wetland, and forested wetland. These subsystems were not analyzed for this project.

Estuarine wetlands support complex and productive ecosystems for critical fish and wildlife habitat. Grasses and sedges are the dominant species in the upper tidal zone. Common plants on the upper beaches include beach-carrot, beach pea, large-headed sedge, paintbrushes, and lupine.

### Riverine

Riverine wetlands includes all wetlands and deepwater habitats contained within a channel, with two exceptions: 1) wetlands dominated by trees, shrubs, persistent emergent and emergent moss or lichens and 2) habitats with water containing ocean derived salts in excess of 0.5%. A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water. Riverine wetlands are associated with riparian areas; however, all riparian areas are not wetlands. Water is usually, but not always flowing in riverine systems. Uplands or palustrine wetlands may occur in the channel, but they are not included in the riverine system. Riverine systems are divided into four subsystems: tidal, lower perennial, upper perennial and intermittent.

## Lacustrine

The lacustrine system includes wetlands and deepwater habitats with all of the following characteristics: 1) situated in a topographic depression or a dammed river channel; 2) lacking trees, shrubs, persistent emergent and emergent mosses or lichens with greater than 30% area cover; and 3) total area exceeds 20 acres. Lacustrine systems may be tidal or non tidal, but ocean-derived salinity is always less than 0.5%. This system includes permanently flooded lakes and reservoirs, intermittent lakes, and tidal lakes with ocean-derived salinities below 0.5%. Typically in SE Alaska, they include large lakes with or without islands of palustrine wetland within the boundaries of the lacustrine system. This system is divided into two subsystems: limnetic and littoral. For the purposes of this project, differentiation between lacustrine subsystems and classes of subsystems is not necessary.

## Palustrine

The palustrine system includes all non-tidal wetlands dominated by trees, shrubs, persistent emergent vegetation, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is less than 0.5%. The palustrine system is bounded by uplands (non-wetlands) or by any of the other wetland systems. The palustrine wetlands are traditionally called muskegs, swamps, bogs, fens, and marshes. It also includes small, shallow, permanent or intermittent ponds. There are no subsystems classified under the palustrine system, but several classes are named and identified as important for this project: moss-lichen wetland, emergent wetland, scrub-shrub wetland and forested wetland.

*Emergent wetlands* class is characterized by erect, rooted, herbaceous plants adapted to saturated conditions (hydrophytes), excluding mosses and lichens. Perennial plants usually dominate them and vegetation is present for most of the growing season. Locally in the project area, these types include bogs (muskegs) and fens. Emergent wetlands are important for a variety of wildlife species, both resident and migratory.

*Moss-lichen* wetland class includes areas where mosses or lichens cover substrates other than rock and where emergent vegetation, shrubs or trees make up less than 30% of the aerial cover.

*Scrub-shrub* wetlands include areas dominated by woody vegetation less than 20 feet tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. Scrub-shrub wetlands may represent a successional stage leading to forested wetlands, or they may be relatively stable communities. Two subclasses for this group occur in the project area: broad-leaved deciduous and needle-leaved evergreen. The broad-leaved deciduous subclass includes areas dominated by Sitka alder or willow. The needle-leaved evergreen subclass include areas dominated by young trees or stunted trees of lodgepole pine, Alaska yellow cedar and western hemlock that typically occur in muskegs or in the transition zone between bogs and forested wetlands. For the purposed of this analysis, all scrub-shrub wetlands are grouped together.

*Forested wetlands* are characterized by woody vegetation that is 20 feet or taller and normally possess an overstory of trees, and understory of young trees or shrubs and herbaceous layer. Forested wetlands are the most common wetland type in the project area. Only one of several subclasses in the forested wetland class exists in the project area: the needle-leaved evergreen. Forested wetlands include a number of forested plant communities with hemlock, cedar, or mixed conifer overstories, and ground cover consisting largely of skunk cabbage and deer cabbage. They produce commercial forest products. These wetlands function as recharge areas for groundwater and streams, and for deposition of sediment and nutrients.

### *Current infestations in wetlands*

Currently, 40% of the infestations of invasive weed species are in wetlands (Foss, 2017). Tall Fescue, Reed canarygrass, Creeping buttercup, Common plantain, common dandelion, annual bluegrass, are common weeds in wetlands.

## *Herbicide Characteristics and their Behavior in Soils*

Herbicides vary in terms of their chemical behavior and the subsequent biological changes which occur in the environment. Once the herbicide is applied, its behavior is a function of soil texture, organic matter content, soil pH, time, temperature, topographic position, and soil moisture. Properties that influence the behavior of herbicides in the environment are summarized below. This summary is based on information provided by Miller and Westra (1998) in Colorado State University Fact Sheet Herbicide Behavior in Soils and Tu et al. (2001) Weed handbook.

### Degradation

Degradation is how an herbicide breaks down in the environment. Most of the herbicides in this EA are broken down by microbial metabolism. They are broken down by two routes: they serve as a food source for the microbes or are metabolized with another food source. Some are decomposed by sunlight, which is called photodegradation. Herbicides may be broken down by various chemical reactions; the most common are hydrolysis and oxidation.

### Immobilization/Adsorption/Soil Retention/Soil Persistence

Herbicide molecules may bind to soil organic matter, iron and aluminum oxides, or clay particles. Different herbicides bind at different rate or strengths to the soils. This can be highly pH dependent. In general, herbicides with pH close to the pH of soil are strongly retained and are not subject to runoff, erosion, and/or leaching. In contrast, herbicides with pH not close to that of the soil are less strongly retained and are subject to runoff, erosion, and/or leaching. If an herbicide molecule is adsorbed or bonded to soil particles it is not available for microbial metabolism and the herbicide remains in the soil for some period of time (e.g. half-life) (Miller and Westra (1998) and Tu et al. (2001).

Soil persistence refers to how long it takes the herbicide to dissipate under normal conditions in the region where the herbicide would be used. This is expressed as the half-life. The half-life can vary significantly depending on soil characteristics, weather (temperature and soil moisture) and the vegetation at the site. Documented soil half-lives for herbicides range from days to months and persistence in the soil depends on several factors: chemical properties of the herbicide; application rate; soil type; presence and activity of soil microorganisms; and climate (SERA Risk Assessments).

### Water Solubility and Volatility

Water solubility is how readily an herbicide dissolves in water and determines the extent to which an herbicide is in the solution (water) phase or the solid phase Water solubility is generally the inverse of soil adsorption—the more water soluble an herbicide is, the less it is able to bind to soils.

Volatility is the tendency of an herbicide molecule to become a vapor. Volatility rates are highest in warm, moist environments. Herbicides with high vapor pressures are likely to escape from the soil and volatilize in the atmosphere. Volatilization most often occurs during application. All of the herbicides proposed in this EA are low to moderate volatility.

For information regarding herbicide effects in water refer to the Hydrology and Aquatic Organisms Resource Reports (Whitacre 2018 and Schneider 2018).

## Toxicity of Herbicides to Soil Microbes

Herbicides vary in their toxicity to non-target organisms, such as soil microbes, herbivores, and aquatic plants and organisms. Chemical treatments typically have some effect on soil biota, but these effects are more or less transitory depending on the timing, frequency, and chemical used. There are limited lab and field studies documenting the toxicity of herbicides on soil microbes. The SERA risk assessments synthesize all known studies; however there is still a lack of definitive information for herbicides on soil microorganisms in the soil environment. In general, effects to individual microbial species and effects to their communities occur at very high concentrations of herbicide in a lab setting. Studies have been too short in duration to determine the true long-term impacts of herbicide use on soil microbes (Tu et al., 2001).

Effects of herbicides on soil microbes may be less severe than the effects of the invasive plant infestation itself. Sylvia and Jarstfer (1997) found that after 3 years, pine trees in plots with grassy invasive plants had 75 percent fewer mycorrhizal root tips than plots that had been treated 3 times per year with a mixture of glyphosate and metsulfuron methyl to remove the invasive plants. In this study the presence of weedy grasses inhibited mycorrhizal abundance more than the use of herbicides.

Table 2 includes the adsorption/mobility properties, solubility rates, degradation rates, and toxicity to microbes for the four herbicides proposed for use in this project. Specific discussion for each herbicide follows Table 2. This information was taken from peer-reviewed literature and SERA risk assessments. The “low” rating displayed in Table 2 is a qualitative rating specific to the toxicity of herbicide residues to soil microbes in the laboratory environment. Herbicides in the low category required concentrations higher than the allowable application rates (per label instruction) before adverse effects to soil microbes were observed. At central application rates (per label instruction), only limited reductions of microbial growth was observed. All herbicide applications proposed under this EIS are in accordance with label restrictions. These conditions are expected to minimize the accumulation of residues in excess of those necessary for effective control of targeted invasive plants and reduce the potential effects of herbicide applications to the soil biota.

Glyphosate and imazapyr come in both terrestrial and aquatic formulations but retain their same chemical characteristics.

**Table 2 summary of herbicides impacts to soils**

| Herbicide | Toxicity to soil Microbes | Adsorption (mobility) | Solubility in water | Degradation path and half life |
|---|---|---|---|---|
| Aminopyralid | Unknown (low to slight on aquatic invertebrates) | Low (very mobile) | Moderate | Soil microbes, sunlight 32 to 533 days |
| Glyphosate | low | Strong (immobile) | Very High | Soil, aquatic microbes 3-149 days |
| Imazapyr | low | Moderate (somewhat mobile) | Very High | Soil microbes 25 to 180 days |

| Herbicide | Toxicity to soil Microbes | Adsorption (mobility) | Solubility in water | Degradation path and half life |
|---|---|---|---|---|
| Metsulfuron Methyl | short-term toxicity with little effects to populations over time | Low (very mobile) | High | Soil microbes, hydrolysis 30-120 days |

### *Aminopyralid*

Aminopyralid is a pyridine group herbicide intended for use in natural and grazed areas. It is a selective, foliage-applied herbicide to control broadleaf weeds. It provides systemic post-emergence broad-spectrum control of a number of weeds as well as provides residual weed control activity reducing the need for retreatment. Aminopyralid has a moderate to low solubility in water and is essentially non-volatile. Aminopyralid photolyzes moderately slowly on surface soils. It has a moderate persistence in the soil, and a moderate potential to leach through soils and contaminate groundwater (EPA, 2005).

The predominant means of aminopyralid degradation in the environment is likely aerobic soil microbial metabolism (half-life 103 days). The resulting products from degradation are two metabolites, oxamic and malonamic acid and the formation of $CO_2$. There is uncertainty in the rate of aerobic degradation in different soils (due to incomplete testing). Potential aerobic soil metabolism half-lives ranged from 31 to 533 days (EPA, 2005).

Limited studies exist on the toxicity of aminopyralid to soil microorganisms. The only one of note shows a negligible to minor suppression of microbial communities at 8.4 mg/kg (ppm). Aminopyralid does not have a long-term affect to soil microorganisms (SERA, 2007-Aminopyralid).

### *Glyphosate*

Glyphosate has high solubility in water and low volatility. Because it readily reacts with clay and metal oxides in soils to form insoluble iron, aluminum and calcium precipitates, it has very high soil retention and low potential for leaching. Plants typically do not absorb glyphosate from soil due to the high retention. Persistence in the soil is short due to the formation of insoluble precipitates, making them biologically inactive upon contact with mineral soils. Studies have found that the half-life of glyphosate ranges from 3-149 days depending upon soil microorganisms (Schuette, 1998).

Glyphosate is readily metabolized by soil microorganisms. Although glyphosate interrupts the same metabolic processes in soil microbes as it does in plants, it does not appear to be harmful to soil microorganisms in field conditions (SERA, 2011a-glyphosate). It has affected growth of soil microbes under lab conditions at very high concentrations (845 mg/L (ppm)) but under lower rates, it has enhanced microbial activity (Haney et al., 2000). Glyphosate has no effect on fungi and only a slight effect to bacteria at concentrations up to 20 ppm (SERA 2011a-glyphosate). Glyphosate does not have a long-term affect to soil microorganisms.

### *Imazapyr*

Imazapyr is a non-selective herbicide; its mode of action is as an acetolactate synthesis inhibitor. Imazapyr does not bioaccumulate or bioconcentrate, it photodegrades in water with a half –life in water of one to two days, and is degraded by soil microbes with a half-life in soil of 25-180 days (SERA, 2011b-Imazapyr). Imazapyr is weakly bound to soil. High organic matter, cool temperatures, and low pH (below 5.0) increase the adsorption to moderate levels, making it low to moderately mobile in soil. Imazapyr is moderately mobile for most native soils on the Tongass which have loamy textures; however in coarse-textured soils, such as those derived from alluvium, colluvium, glacial till and/or gravel fill (such as the case along roads and trials), it is highly mobile due to low clay and organic matter content. It can be exuded into soil from roots of treated plants; plants can absorb imazapyr from soil because it is not tightly bound like glyphosate. Similar to aminopyralid, it is active in soil as a pre-emergent. Aquatic formulations allow this herbicide it to be used in within the water column, along stream sides and intermittent drainages, flood plains, bogs and other wetlands.

Despite the potential for mobility and leaching, imazapyr degrades quickly in water by sunlight so water contamination is minimized.

Imazapyr was toxic to various soil microorganisms in a laboratory setting. Lab and field studies of imazapyr have shown a slight suppression or inhibition on some soil microorganisms at 2.6 to 26 ppm while some were not affected at 260 ppm (SERA, 2011b-Imazapyr). Effects on bacteria are species-specific; lab experiments are poor indicators of impacts in the field environment. Field studies showed that there was a slight effect to soil microbes at 20 mg/kg (ppm) and a substantial impact at 150 mg/kg (ppm) (SERA, 2011b-Imazapyr). Imazapyr does not persist in humid environments and binds to soil organic matter. Because most soils in the project area contain high organic matter content, the long term effects to soil microorganisms is expected to be negligible.

# Environmental Consequences

Invasive plant treatments can have direct, indirect and cumulative effects on soil properties. Direct effects occur immediately or soon after the implementation of the action, such as alteration of soil physical, chemical and biological properties as a function of treatment type. Indirect effects are those effects that are “reasonably likely” to occur in a location spatially separated from the action or at a later point in time after a projects implementation, such as changes in soil biota downslope from herbicide applications sites. Cumulative effects include the sum of the direct and indirect effects from current projects, past projects, or project that are expected to occur in the near future and include both National Forest Service (NFS) and non-NFS lands (if known). Past projects considered in the cumulative effects analysis are generally physically located within the cumulative effects analysis area.

The direct, indirect and cumulative effects from the use of any treatment method (manual, mechanical and chemical) depends on the type (its disturbance level, toxic properties/hazards), and extent (the area of disturbance and level of exposure to the herbicide at any given time, and the duration of the exposure).

The effects of invasive plant treatments on soil quality, site productivity and the consequences of soil erosion and changes in the microbial population as a function of treatment methods vary greatly. The effects of manual and mechanical treatment methods can oftentimes be more extensive than the effects of herbicide use because of the degree of soil disturbance that may be involved with the treatment method. This section evaluates the effects of both manual/mechanical treatments as well as herbicide treatments by looking at the direct, indirect and cumulative effects of each treatment methods.

Overall, effects of the proposed herbicide applications on the soil resource are expected to be negligible over the Northern Tongass project area. Some adverse effects from these actions include localized, short-term effects on soil microorganisms and thus, soil productivity. Effects to soil microorganisms are primarily the result of the inherent toxicity and persistence of chemical residues. Changes to the vegetative cover or levels of soil disturbance from manual or herbicide treatments can affect the site quality, soil productivity and levels of soil erosion at the site.

All treatment areas in this project will be relatively small areas that are discontinuously scattered across many acres of the landscape. The impacts from any one treatment will be highly localized. Overall, effects to the soil resource are minimal. Site quality and soil productivity will be maintained as a result of project design features included in the EIS. Design features limit the degree of physical disturbance of a site, limit the herbicide application to label recommendations and include other provisions to minimize adverse effects to soil microbial communities, minimize the potential for increased soil erosion and any adverse impacts to wetlands.

## Spatial and Temporal Context for Effects Analysis

The spatial context for this analysis of effects includes the project area, which includes all NFS and non-national forest system lands. The temporal context for cumulative effects is a period of both short-term, being one growing season (or seasonal treatment of a site), and long-term, being one or more years up 20 years.

Past, present and reasonably foreseeable activities that are relevant to soil and wetland resources in the project area were considered. Projects that have occurred and will likely continue in the project area include a few timber sales, thinning, road and trail maintenance, mineral extraction, construction of developed recreation sites and renewable energy development.

Cumulative effects occur in places where the same ground is treated multiple times—either with herbicide or mechanical treatments.

### *Indicators Used to Assess Effects*:

- Potential for soil disturbance from manual or mechanical treatments resulting in losses to site quality and/or site productivity;
- Potential for toxicity to microbes from herbicides and resulting effects to soil productivity;
- Potential for soil erosion from treatment methods.

### *Analytical Methods for Herbicide Effects*

Effects displayed in this analysis specific to herbicide characteristics and pathways are primarily derived from herbicide risk assessments (SERA, 2007, 2011a, and 2011b). These assessments contain pertinent information, when available, on the potential effects of herbicide applications on soil organisms, studies considered for the risk assessments, models of individual herbicide movement, and specific information about herbicide properties such as persistence, adsorption rates to mineral soil or organic matter, and solubility in water.

#### GLEAMS Model

GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) is a model that allows examination of the fate of pesticides in various soils under a variety of environmental conditions. This model includes a large number of variables that can be changed via a user-friendly interface. This model was used at five sites on the northern portion of the Tongass N.F.

The project record include information about the data used in the model. The model was run based on the GLEAMS drivers Cheat Sheet from Region 6 (Bautista, 2015).

The GLEAMS model analyzes soil using soil texture as one variable to predict herbicide movement and fate in the soil profile. For this analysis, we used coarse sand as the soil textural class in the model. Coase sand was chosen because many of the known infestation sites that are planned to be treated are composed of gravel/fill material commonly used for road construction and various developed sites, such as trails, recreation sites, administrative and special use sites. In addition, because coarse-textured soils (e.g. sand and gravel) do not have the same physical properties as finer-grained soil particles (e.g. clay and organic matter), herbicides cannot be held to the soil particles in the same way as soils with finer textures; therefore, the herbicides more readily enter the soil solution and is moved through the system by percolation and/or lateral movement downslope. Because of the electrical charge of finer-grained soil particles, such as clay and highly decomposed organic matter, herbicide will bind to these soil components and be held in situ for some time (half-life).

# Alternative 1

## *Direct and Indirect Effects*

Under this alternative, existing small scale manual and mechanical treatments such as hand pulling and tarping would continue. A minor amount of herbicide use will continue on administration sites and recreation sites (36 CFR 220.6).

Under this alternative, the continued persistence of invasive plants can adversely affect soil physical conditions due to changes in vegetation cover and root biomass. The decreased root mass may affect soil organisms and could lead to increased soil erosion. Invasive plant infestations may also impact microbial communities more than herbicide treatments as found in mycorrhizal communities by Sylvia and Jarstfer (1997).

Disturbed soils, from management activities or through erosion, are likely to be colonized by invasive plants near the disturbance. If populations are left untreated or minimally treated they may inhibit colonization by native or desired plant species.

There may be indirect effects resulting from decreased quality and quantity of vegetative cover in areas with dense invasive plant infestations. Invasive plants sometimes have lower surface cover than native species. Soil erosion increases in areas with reduced soil cover so untreated, infested areas may have increased soil erosion in localized areas but not large enough to be considered detrimental to soil productivity. Also, accelerated erosion and other disturbed soil provides an environment where invasive plants can flourish.

## *Cumulative Effects*

The past, present, and foreseeable activities that affect the soils and wetland resources include ground-disturbing activities from mining, timber harvest, thinning, road building and maintenance, trail building and maintenance, and recreation activities. Increased levels of disturbance from these activities may have an adverse effect on soil microbial populations. These projects may also increase soil erosion but through effective BMP implementation we avoid detrimental effects to site quality. In summary, there is a negligible cumulative effect to soil quality and site productivity to soil resources, including wetlands, as a result of soil erosion or loss of soil microbes for Alternative 1 due to the low rates of erosion in the project area, effectiveness of BMPs and the minor use of herbicides in the past, as well as for the present and future.

Absence of invasive plant management could cause short-term negative effects to soils and associated physical and biological components and processes. Impacts to soils could increase over the long-term due to the continued growth of current infestations and the establishment of new populations.

## Manual/Mechanical Treatments plus Herbicide (Alternatives 2 and 3)

This method proposes both herbicide and manual/mechanical treatments. Table 3 provides a range of application rates (per label instruction) for each proposed herbicide proposed in this project. Broadcast spray targets an area rather than individual plants. This treatment method uses a backpack sprayer, OHV-mounted sprayer, or truck-mounted boom sprayer which can impact non-target plants. Spot spraying generally is accomplished with a backpack or hand-held spray device. Hand/selective methods treat individual plants, reducing the potential for herbicide to impact soil or non-target organisms. Hand/selective methods treat individual plants and include wicking and wiping; foliar application; basal bark treatment; frill, hack, and squirt, stem injection, and/or cut-stump methods.

**Table 3. Proposed application methods and rates for herbicide application**

| Herbicide | Application method | Label-based Typical Application Rate Lb. a.i./acre |
|---|---|---|
| Glyphosate, Aquatic formulation | Broadcast spray, spot spray, hand/selective | 0.5-8.0 |
| Imazapyr - Terrestrial | Broadcast spray, spot spray, hand/selective | 0.03-1.5 |
| Imazapyr, Aquatic formulation | Broadcast spray, spot spray, hand/selective | 0.03-1.5 |
| Aminopyralid | Broadcast spray, spot spray, hand/selective | 0.078-0.11 |
| Metsulfuron Methyl | backpack directed foliar | 0.00125-0.15 |

### *Direct and Indirect Effects*

This alternative proposes an integrated pest management approach, using all available treatment methods (manual, mechanical and chemical) in combination with an early detection and rapid response (EDRR) system of treatment within the project area. Early detection-rapid response is considered in this direct, indirect and cumulative effects analysis.

Effects from herbicide application to soil resources are negligible, and short-term according to the analysis provided below. The best methods to control potential adverse effects from herbicide treatment are through the use of Project Design Features (PDF's) and by following manufacturer's label instructions. Direct and spot spray treatment methods also minimize the amount of herbicide needed to treat invasive plants. PDFs to reduce impacts to soil are provided below and include developing an herbicide transportation, handling, and emergency spill response plan, having a spill kit on site when herbicide treatment methods occur, and limiting the amount of herbicide used to the minimum amount required to be effective. Soil type and aquatic or terrestrial formulations will also be determined prior to treatment and treatments planned accordingly. With these measures in place, the risk to soil properties is low.

Mechanical effects are discussed after the chemical effects below. There is a minor effect to the soils and wetlands resources from using both manual and herbicide treatments because there is a risk of leaving large areas of soil bare from treatment. Bare soils are a source of sediment if they are not covered with plant residues, erosion control treatments, or native vegetation. The minor effect is expected to last until the site has been colonized by native vegetation.

## Results of the GLEAMS Model on Soil Properties

To analyze the effects of the three proposed herbicides on soil resources and wetlands, we used the GLEAMS model on five sites located on the northern Tongass[1] (Table 4) which represented known invasive plant infestations. All of these sites are developed sites constructed in shot rock or gravel. Coarse sand was selected as the soil textural class in the GLEAMS model to represent the gravel and shot rock conditions. The results of the model for the five sites related to effects on the microbial population are discussed below. Studies on the impacts of herbicide on soil microbial communities are limited; therefore in-depth interpretations of model results are also limited.

We used the highest herbicide application rate (per label instructions) for the five sites modeled. Since the herbicide would be applied at substantially lower rates than those modeled (e.g. Label-based typical application rates shown in Table 3), actual concentration in the soil will be much lower than modeled as a worst case scenario. In reality, the highest application rates would only be used under very specific conditions, such as stem injection of Japanese knotweed or broadcast spray of oxeye daisy during flowing. The results of the model indicates that herbicide concentration levels are all substantially lower than concentrations levels that may affect soil microbial populations (SERA, 2007, 2011a, 2011b) (Table 4).

**Table 4. GLEAMS model outputs for herbicide concentration at 12" and 36" soil depths and the depth the herbicide penetrates.**

| Herbicide | Site Name | GLEAMS Highest Concentration at 12" soil depth | GLEAMS Highest Concentration at 36" soil depth | GLEAMS Soil penetration depth | SERA Literature Effects to Soil Microbes[1] |
|---|---|---|---|---|---|
| | | (ppm) | (ppm) | (in) | (ppm) |
| Aminopyralid | Freshwater, Skagway | 0.2 | 0.067 | 60 | 8.4 |
| Glyphosate | Ahrnklin, Yakutat | 8.49 | 2.83 | 19.4 | 20 |
| Glyphosate | Corner Bay, Freshwater, Skagway | 8.40 | 2.80 | 13.6 | 20 |
| Imazapyr | Ahrnklin, Yakutat | 2.88 | 0.97 | 60 | 20 |
| Imazapyr | Corner Bay, Freshwater, Skagway | 3.45 | 1.20 | 60 | 20 |

[1] Because soils are similar in texture, moisture and depth, the five sites on the northern Tongass represent similar conditions on POW Island and were therefore considered appropriate for use in this analysis.

1. Sera Risk Assessments for Aminopyralid, Glyphosate, and Imazapyr (SERA 2007, 2011a, 2011b).

## Effects of Herbicide and Adjuvants on Soil Solution and Microbes

Several herbicides are mobile in the soil and have a high leaching potential, especially in gravel fill or shot-rock roads (Table 5). Aminopyralid, imazapyr and metsulfuron methyl all leach readily into the soil and should be minimized on shot rock fills where the water table is high. Most of the treatment areas are very porous shot-rock roads or shot rock or gravel-filled admin sites. Here, water flushes through this material very easily and any herbicide that's prone to leaching will end up in groundwater. Because the environment of Southeast Alaska has continuous water input to all systems, this solubility and movement of herbicides through the soil profile may be thought of as a continuously dynamic process where the soil solution is constantly receiving inputs of additional water and thus has a continuous dilution factor to concentrations of any chemical input. For more details on the effect of these herbicides on water, see the hydrology resource report for this project (Whitacre 2018). For roads, trails, administration and recreations site types, treatment areas are composed of very porous shot-rock or gravel-filled substrate. These site types will have higher rates of herbicide movement through the system than other sites types that have soils with higher amounts of organic matter and/or finer-textured soils.

See above discussion on effect of herbicides on soil organisms and Table 5 for a summary of results of the four proposed herbicides on soil properties. Herbicides are typically used with adjuvants, compounds which enhance the capability of the herbicide to stick and spread over vegetation and to penetrate into plant tissues. Adjuvants vary in toxicity and few studies have been conducted on their behavior in the environment. To reduce the risks associated with adding an adjuvant, a PDF was developed to require that low-risk aquatically approved surfactants be used during implementation. The amount of any adjuvant used would make up a small percentage of the herbicide mixture, keeping the effects on the environment, including soils, within the same range as the herbicide being used (Bakke, 2007).

**Table 5. Herbicide effects in the soil from proposed herbicides at typical application rates.**

| Chemical Name | Microbial impacts | Effects to adjacent vegetation | Leaching in high OM soil | Leaching in low OM gravels |
|---|---|---|---|---|
| **Aminopyralid** | Unknown if toxic to soil microorganisms. | selective, all broadleaf | High | High |
| **Glyphosate** | Non-toxic to soil microorganisms | Non-selective, may affect non-target vegetation | Low, should not be used prior to predicted rainfall. | low |
| **Imazapyr** | Non-toxic to soil microorganisms. | Non-selective, may affect non-target vegetation | Low-Moderate | Moderate-High |
| **Metsulfuron methyl** | Short term toxicity at high rates | selective, most broadleaf, can damage conifers | High | High |

## Toxicity to Microbes from Herbicides

Alternatives 2 and 3 propose the application of four different herbicides across the northern Tongass National Forest. The four herbicides proposed for use all have a low risk of toxicity to soil microbes when applied at the typical or highest application rates analyzed in the SERA Risk Assessments for each herbicide. Aminopyralid, glyphosate, imzazpyr, and metsulfuron methyl have a negligible effect to soil microorganisms at the typical application rates as well as the modeled high application rates (Table 4). Project Design Features were developed to minimize the effects of these herbicides.

The degradation pathway for all proposed herbicides is primarily by microbial degradation. These are complex biochemical reactions that ultimately turn the herbicides into inert salts and carbon dioxide. Although studies have been conducted on the direct effects of herbicides on soil microbes, information about the effects of specific herbicides to each of the thousands of soil organisms is not available. However, evidence from research on the effects of residues produced by typical application rates shows negligible effects to soil microbes under field conditions. Effects that have been identified are generally not measurable by quantified losses of microorganisms in the soil environment (Busse et al. 2001). Although laboratory research shows direct toxicity of most herbicides to soil microbes when applied at increasingly higher concentrations in solution (Estok et al. 1989; Chakravarty 1987), direct effects on growth rates of microbes do not appear to be significant until concentrations higher than those possible under legal application rates (Estok et al. 1989; Chakravarty 1987). Changes to microbial and fungal populations from herbicides applied at rates proposed in this EA are likely to be transitory (Roslycky 1982; Tu 1994), and do not appear to inhibit the long term health of microbial populations in the soil (Tu et al. 2001) or the productivity of treated sites (Ratcliff 2006).

### Soil Productivity

None of the herbicides under consideration for use has been shown to have a notable effect on soil productivity. Additionally, studies on the effects of herbicides on mycorrhizal fungi and bacterial populations indicate relatively low impacts to microbial populations from herbicides, even from multiple applications (Busse et al., 2001).

Potential effects to soil microbes and organic matter input are used as surrogates for soil productivity in this analysis. Soil productivity is likely to be maintained on treated sites due to the low toxicity of herbicides on soil microbes when applied at and below recommended label application rates. The application of herbicide on invasive plants would also promote the growth of native species which is the desired condition for soils.

### Erosion Potential from Treatment Methods

Accelerated erosion is an indirect effect of invasive plant treatments with its greatest impact on site quality. With the use of herbicides, treatment areas may be more extensive than treatment areas using manual or mechanical methods (described below). Additionally, dense populations of invasive plants may be treated more effectively using herbicides, resulting is larger continuous un-vegetated areas after treatment. Natural re-colonization of native vegetation will take several years if treatments are not followed up with some type of restoration activity. If vegetative cover is absent and soils are exposed to the physical impacts of water via rain or overland flow, erosion and subsequent sedimentation in or near a water body may occur. If soil cover is maintained, even by dead invasive plants, new native plants, or other erosion control, the risk of erosion is minimized.

Herbicides selectivity (the ability of an herbicide to impact certain plant types) and application method can indirectly effect soil erosion. Non-selective herbicides kill more than just the target vegetation. If a non-selective herbicide is applied to a large area, it may kill all vegetation on site, leaving the soil bare and increasing the risk of soil erosion. The highest risk to more extensive and continuous de-vegetated sites comes from broadcast spray treatment methods. PDFs limiting herbicide to the minimum required rates, spray calibration, and weather minimums minimize, but do not eliminate the risk of killing native vegetation.

Because soil erosion may be a detrimental effect to site quality, herbicide usage may also be tied to site quality. In addition, other detrimental effects to soils as a result of physical disturbances created during herbicide application may affect site quality. These disturbances include compaction, churning and puddling caused by human trampling as well as use of vehicles. Off-road vehicles may be used with broadcast spraying in limited situations where it is deemed most effective. With spot spray, direct spray and even broadcast spraying using a backpack, these disturbances to soil quality are likely to be minimal and are not anticipated to exceed soil quality standards for detrimental effects defined in FSM 2554.

### Wetlands

The effects to wetlands are similar to those listed for soils above. About 40 percent of current infestations are in wetlands so using appropriate herbicide formulations will be important. Project design features combined with label instructions for use of herbicides in wet environments will minimize any adverse impacts of chemicals to the values and functions of wetlands in the project area. Additional mitigation opportunities, such as reseeding and other site restoration practices, should be used to compensate for any disturbances in these and all wetlands.

## *Cumulative Effects*

The past, present, and foreseeable activities that affect the soils and wetland resources include ground-disturbing activities from mining, timber harvest, thinning, road building and maintenance, trail building and maintenance, renewable energy, and recreation activities. In addition, these projects may increase soil erosion; however effective BMP implementation across the Tongass (USFS, 2016 and 2017) ensures soil erosion is minimized. The proposed use of herbicides combined with past, present, and reasonably foreseeable actions is or is expected to result in negligible effects on the soil and wetland resources in the project area.

Sites with persistent invasive vegetation may need to be treated for a period of years. Most herbicides have a half-life much lower than 1 year and do not tend to persist in the soil or aquatic environment. There would be a minor effect to soil productivity and wetlands because the PDFs minimize impacts to these resources and herbicides would be used on a relatively small area on the landscape.

Effects are expected to be highest as continued treatments of previously treated sites are combined with initial treatment of new sites or places that need to be treated multiple times per year. However these effects are negligible to minor because of the relatively small areas proposed for treatment by either herbicide or manual/mechanical methods and the efficacy of the PDFs. The level of negative impact would be expected to decline in relation to the progressive reduction in the total area of infestations that receive treatment over time. Effects would never be completely eliminated because surveys will likely reveal new infestations and additional treatments will occur.

The cumulative effects from manual, mechanical and chemical treatments would also be negligible considering the implementation of soil and water BMPs which are designed to avoid any detrimental effects of mining, timber harvest, thinning, road building and maintenance, trail building and maintenance, renewable energy, and recreation activities on soil quality. Further, eradicating invasive plants would allow re-colonization of native plants and thus improvement of soil conditions and resiliency.

### Early Detection / Rapid Response (EDRR)

Herbicide treatments using EDRR would not exceed or change any of the effects described above regardless of when the treatments occurred. If effective treatments of new infestations required herbicide treatments outside the scope of the project, or if PDFs could not be applied without a significant loss of effectiveness, further analysis would be required.

# Manual/Mechanical Treatments (All Alternatives)

Overall adverse impacts from non-herbicide treatment activities to soil quality would be negligible and short-term due to the relatively small size of the treatment areas.

## *Direct and Indirect Effects*

The effects to the soil and wetlands resources from manual or mechanical treatments are anticipated to be negligible. There would be negligible effect to the soil microbial populations, thus effects on soil productivity would be negligible. Site quality may be affected because it is a function of the detrimental effects to soil physical properties (FSM 2554) such as compaction, puddling or wetting that may occur through manual and/or mechanical treatments. However, these effects will be minimized though the use of soil and water BMPs (FSH 2509.22) and site-specific project design features (PDFs).

Hand pulling and mechanical treatments may expose bare soil. Exposing bare soil may result in increased soil erosion, and depending on how treatments are conducted the soil could be compacted or displaced. Hand pulling, pulling using tools, clipping and cutting, torching, and tarping have similar impacts including ground disturbance due to foot traffic, dislodging sediments into streams, creation of foot trails, and creating areas of bare, disturbed ground. Hand treatments typically require multiple entries, possibly several per year, increasing the potential for these effects. Hand pulling and pulling using tools, would result in the greatest amount of soil disturbance compared to clipping and cutting or tarping. PDF 28 addresses erosion control and should be effective in minimizing erosion and sedimentation.

Tarping may reduce the number of soil microorganisms near the ground surface due to the heat generated by the tarp. This effect would be confined to the upper one or two inches of soil because soil is a poor conductor of heat. The heated zone should quickly re-colonize with microorganisms from surrounding unaffected populations after tarps are removed. The effect to soil site quality from mechanical only treatments is negligible.

### Wetlands

The effects of manual and mechanical treatments to wetlands are similar to those listed for other non-wetland soils above. Project design features will minimize any adverse impacts of site disturbance to the values and functions of wetlands in the project area. Additional mitigation opportunities, such as reseeding and other site restoration practices, should be used as appropriate to compensate for any disturbances in these and all wetlands.

## *Cumulative Effects*

The cumulative effects of manual and/or mechanical treatments would be negligible considering the implementation of soil and water BMPs which are designed to avoid any detrimental effects of mining, timber harvest, thinning, road building and maintenance, trail building and maintenance, and recreation activities on soil quality. However the total amount of soil disturbance as a result of past, present and foreseeable activities combined with the effects of invasive plant manual and/or mechanical treatments is difficult to assess. Surface erosion may increase shortly after treatment due to bare soil being exposed to rain. This would occur until the site is revegetated.

## Conclusions

Overall, the effects of proposed herbicide applications on the soil resource are not expected to be measurable although some adverse effects from these actions are unavoidable and include localized, short-term effects on soil microorganisms and soil productivity. Effects to soil microorganisms are associated with the inherent toxicity and persistence of chemical residues, which is negligible according to the information available. Changes to the vegetative cover or levels of soil disturbance from manual, mechanical or herbicide treatments can affect soil productivity and soil erosion.

Effects to the soil microbial communities, soils, and wetlands are minimized and soil productivity would be maintained as a result of project design features. Design features limit the herbicide application to label recommendations and include other provisions such as the new National Best Management Practices for Water Quality Management on National Forest System Lands (http://www.fs.fed.us/biology/resources/pubs/watershed/FS_National_Core_BMPs_April2012.pdf).

# Project Design Features (PDFs)

Project design features were developed to minimize the potential for adverse effects on soil during the implementation of this project. Herbicide treatments would be applied in accordance with label instructions, USDA Forest Service policies, Forest Plan management direction, and other human health and/or ecological PDFs.

Project implementation, following the design features developed to protect soils and wetlands, is anticipated to have minimal effects due to the limited extent of the activities and the constraints built into the project, including the National Best Management Practices for Water Quality Management on National Forest System Lands (http://www.fs.fed.us/biology/resources/pubs/watershed/FS_National_Core_BMPs_April2012.pdf).

### Soils and Wetlands

1. Review treatment plans with the District/SO Soil Scientist.
2. Determine the suitability of the soil and wetlands for each type of herbicide prior to implementation. Use only aquatic formulations in wetlands and on sites with seasonally high water tables.
3. Soil disturbance should be kept to a minimum. If an area greater than 100 square feet of mineral soil is exposed by pulling or burning, a Tongass Soil Scientist should be consulted to review and make mitigation recommendations. Avoid using a weed torch on dry days. Adhere to R10 Soil Quality Standards.
4. Apply erosion control measures (e.g., silt fences) and native revegetation (e.g., mulching, native grass seeding, planting) for manual treatment where detrimental soil disturbance or de-vegetation may result in the delivery of measurable levels of fine sediment.
    a. Use: R10 BMPs: 12.5, 12.17, 14.8 and 14.25; and

   b. National Core BMPs: AqEco-2, Veg-2, Veg-8, Chem-1, Chem-2, Chem-3, Chem-4, Chem-5, Chem-6, and Fac-6.
5. Revegetation, if determined necessary, will follow current Tongass National Forest standards for seed mix outlined in the Guidance for Invasive Plant Management Program (USDA 2017c).

# Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

All alternatives in this environmental assessment meet or exceed Forest Plan Amendment, 2016 Standards and Guidelines, and are consistent with State and USDA Forest Service laws and regulations.

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