Soils

Affected Environment

Soils are an integral part of ecosystems, ecosystem function, and the above and below ground interaction of organisms. Soil formation in the Pacific Northwest is dominated by glacial and volcanic influences leading to a large variety of soil types with differing levels of inherent productivity with a wide diversity of soil types from the minimally developed, nutrient-poor soil and rock outcrop complexes of the steep mountain slopes and ridges to the deep, fertile soils of the lower valleys. Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation and ecosystem health. Soil productivity is the inherent capacity of the soil resource to support appropriate site-specific biological resource management objectives, which include the growth of desirable plant species, plant communities, or a sequence of plant communities, all to support multiple land uses and ecosystem services (Adhikari and Hartemink 2016; Greiner et al 2017). Six soil functions have been identified by the Forest Service for maintenance of soil quality and productivity: soil biology, soil hydrology, nutrient cycling, carbon storage, soil stability and support, and filtering and buffering. In order to provide multiple uses and ecosystem services in perpetuity, these six soil functions need to be active and effectively working. These functions all contribute to ecological resilience, especially in riparian systems. In most areas where restoration actions are being proposed, at least one of these soil functions has been impacted or impaired by prior management activities.

Soil Quality and Productivity Issues for Analysis

Riparian and aquatic restoration categories with ground disturbing activities would impact soil properties, such as bulk density and infiltration, potentially causing short-term detrimental soil conditions but long-term leading to an improvement in ecosystem processes and restored soil function. Restoration of soil function will improve soil quality and productivity providing for long-term ecosystem services.

Issue Indicator for Analysis – Improved Soil Function

Acres of improved soil function will be used as the first indicator for soil quality and productivity. The core idea is that maintenance or improvement of soil functions, and therefore soil quality and productivity, provides for ecological services.

Methodology: Soil productivity and function are discussed qualitatively for the proposed action in the following sections. The project footprint for most restoration activities will result in at least that many acres of improved soil function and ecosystem processes (Gregory et al 1991; Poff et al 1997; Stromberg et al 2007; Tabacchi et al 1998). Area of improved soil function for the projects is calculated using the following information for each type of project.

Aquatic Organism Passage Projects

- Fish passage restoration projects would result in at least 1,500 feet of floodplain connection for movement of sediment and debris and will be restored resulting in 1 acre of improved soil function.

- Small dam removal projects would restore inundated soils and provide floodplain connection for transport of sediment and debris. Average small dam removal project footprint of 4 acres was determined by a survey of experienced restoration specialists in the Pacific Northwest Region.

In-channel, Side-channel, and Floodplain Projects

- Beaver dam analogues would increase and/or restore wetland habitat and riparian function. Beaver dam analogue project footprint of 1 acres was determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Bull trout protection would have no impact to soil function.
- Channel reconstruction/relocation projects would restore disturbed soils and provide floodplain connection for transport of sediment and debris. Channel reconstruction/relocation project footprint of 1 acres was determined by an analysis of ARBO II projects from 2013-2017.
- Fence and stream crossings to protect aquatic restoration projects would result in minimal impact to soil function.
- In-channel nutrient enhancement would have no impact to soil function.
- Large wood, boulder and gravel placement average project footprint of 29.6 acres was determined by an analysis of ARBO II projects from 2013-2017.
- Legacy structure removal would restore disturbed soils and provide floodplain connection for transport of sediment and debris. The project footprint of 0.5 acres was determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Off- and side-channel habitat restoration would restore disturbed soils and provide floodplain connection for transport of sediment and debris. An average project footprint of 8.7 acres was determined by an analysis of ARBO II projects from 2013-2017.
- Piling and other structure removal would have minimal impact to soil function.
- Reduction and rehabilitation of recreation impacts would restore disturbed soils and establish appropriate riparian vegetation with an average project footprint of 10.9 acres determined by an analysis of ARBO II projects from 2013-2017.
- Setback or removal of existing berms, dikes, and levees would restore disturbed soils and provide floodplain connection for transport of sediment and debris. An average project footprint of 12.7 acres was determined by an analysis of ARBO II projects from 2013-2017.
- Streambank restoration would restore disturbed soils and provide floodplain connection for transport of sediment and debris. The average project footprint of 25.3 acres was determined by an analysis of ARBO II projects from 2013-2017.

Riparian Vegetation Projects

- Beaver habitat restoration would increase and/or restore wetland habitat and riparian function. An average project footprint of 1.0 acres was determined by an analysis of ARBO II projects from 2013-2017.

- Juniper removal projects would restore the vegetation dynamics to the site and provide for increased soil function on a footprint of 10 acres determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Riparian vegetation planting would restore the vegetation dynamics to the site and provide for increased soil function with an average project footprint of 5 acres was determined by an analysis of ARBO II projects from 2013-2017.
- Riparian vegetation treatment and controlled burning would restore the vegetation dynamics to the site and provide for increased soil function on an average project footprint of 100 acres was determined by an analysis of ARBO II projects from 2013-2017.

Road Decommissioning Projects:

- Nonsystem road decommissioning is assumed to restore soil function on an average width of 20 to 25 feet, which results in an average of 3 acres per mile restored.

Issue Indicator for Analysis – Detrimental Soil Conditions

Acres of short-term detrimental soil conditions will be used as the second indicator for soil quality and productivity. Detrimental soil conditions include soil disturbance that results in a short-term impairment of soil productivity and function such as compaction, puddling, displacement, severely burned soils, and eroded sites (FSM 2520 R6 Supplement 2500-98-1).

Methodology: Short-term detrimental soil conditions are anticipated to occur with all the activity types causing ground disturbance with heavy equipment or fire. Projects with ground disturbance will be reviewed by a soil scientist for compliance with forest plan and regional soil quality direction. Detrimental soil conditions are assumed to occur where large equipment and/or fire is used for restoration activities. Calculations of detrimental soil conditions are made for this analysis based on the following assumptions:

- Staging areas are assumed to be 0.25 acre for all projects determined by a survey of experienced restoration specialists in the Pacific Northwest Region.

Aquatic Organism Passage Projects

- Fish passage restoration projects occur primarily within the road footprint therefore the only additional detrimental soil conditions would be the staging area for equipment.
- Small dam removal projects would result in detrimental soil conditions within the project footprint and an additional staging area.

In-channel, Side-channel, and Floodplain Projects

- Beaver dam analogue would result in detrimental soil conditions in a staging area.
- Bull trout protection would have no impact resulting in detrimental soil conditions.
- Channel reconstruction/relocation projects would have detrimental soil conditions in 10 percent of the project area and additional staging area determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Fence and stream crossings to protect aquatic restoration projects would result in minimal detrimental soil conditions.

- In-channel nutrient enhancement would have no impact resulting in detrimental soil conditions.
- Large wood, boulder and gravel placement would have detrimental soil conditions in 10 percent of the project area and additional staging area determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Legacy structure removal project would result in detrimental soil conditions within the project footprint and an additional staging area.
- Off- and side-channel habitat restoration would have detrimental soil conditions in 10 percent of the project area and additional staging area determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Piling and other structure removal would have minimal impact resulting in detrimental soil conditions.
- Reduction and rehabilitation of recreation impacts would result in detrimental soil conditions within the project footprint and an additional staging area.
- Setback or removal of existing berms, dikes, and levees would have detrimental soil conditions in 10 percent of the project area and additional staging area determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Streambank restoration would have detrimental soil conditions in 10 percent of the project area and additional staging area determined by a survey of experienced restoration specialists in the Pacific Northwest Region.

Riparian Vegetation Projects

- Beaver habitat restoration would have minimal impact resulting in detrimental soil conditions.
- Juniper removal would have detrimental soil conditions in 5 percent of the project area determined by a survey of experienced restoration specialists in the Pacific Northwest Region.
- Riparian vegetation planting would have minimal impact resulting in detrimental soil conditions.
- Riparian vegetation treatment and controlled burning would have detrimental soil conditions in 5 percent of the project area determined by a survey of experienced restoration specialists in the Pacific Northwest Region.

Road Decommissioning Projects:

- Non-system road decommissioning would result in detrimental soil conditions within the project footprint and additional staging area.

Spatial and Temporal Boundaries

Spatial: The appropriate geographic area for soil effects analysis is the land area affected by a management activity. This is because soil productivity is a site-specific attribute of the land. The productivity of one area of soil is not dependent on the productivity of an adjacent area of land. Similarly, if one acre of land receives soil impacts resulting from management activities and a second management activity that may affect soil is planned for that same site, then soil

cumulative effects are possible on that site. Thus, cumulative effects to soil productivity are appropriately evaluated on a site-specific basis.

Temporal: The temporal scope for assessment of soil resource environmental effects includes both short- and long-term impacts. For the purposes of this analysis, short-term effects are defined as those that occur approximately within 1 to 15 years following proposed management actions. Long-term effects are defined as those that occur approximately 15 or more years following proposed management actions.

Current Condition

Historically (before European settlement) and without human-caused disturbances, soil loss, soil compaction and nutrient cycling would probably have been within functional limits to sustain soil quality and maintain soil productivity for most soils. The exception to this could during times of drought when there might be relatively short-term effects to soils from wildfire.

Much of the current soil condition at sites needing restoration actions are related to past management resulting in both physical changes in the soils as well as altered disturbance regimes in the systems. Management activities that have affected soil condition include timber harvesting, site preparation, mechanical fuels treatments, prescribed fires, road construction and use, recreation facility maintenance and use, grazing, and special uses among others. Physical changes in the soils from these activities include compaction, loss of organic matter, severely burned soils, and erosion. All of these disturbances have impacted the soils and soil function to varying degrees. The departure from the natural disturbance regimes in both flooding and deposition as well as ecosystem disturbances (such as lack of wildfire) has caused these systems to change. Over the last century, fire suppression and other management activities have altered the structure and function of forests and rangelands across much of the western United States (Belsky and Blumenthal 1997; Dwire and Kauffman 2003; Hessburg et al 2005). Forest structure and composition has been most significantly altered due to the lack of fire disturbance. The disruption of the natural fire intervals of the past have resulted in higher stand densities, multi-layered stands of mostly one species in places and encroachment of conifers into meadows and grasslands. Dramatically higher stand densities and development of ladder fuels increase the risk of uncharacteristically severe wildfire, bark beetle infestations, and in some areas successional replacement by shade-tolerant competitors. These changes including higher tree density, more multi-storied stands and ladder fuels, and a greater homogeneity of structures across the landscape result in a greater probability for disturbances to affect large contiguous areas. In addition, riparian vegetation has been impacted by invasive species, lack of floodplain connection and changes in water table depth. The lack of floodplain connection and natural flooding and deposition regimes has hindered the establishment and maintenance of desired riparian conditions in many locations and, therefore, valley bottoms do not have the array of wetlands and terraces found in undisturbed locations (Palmer and Bernhardt 2006).

Environmental Consequences

Direct and Indirect Effects

Bull trout protection and in-channel nutrient enhancement were not analyzed for effects to the soil resource. These two activities neither cause ground disturbance nor restore soil functions and therefore no effects to soils are anticipated from these activities.

Activity types that restore disturbance and disturbance regimes into the riparian areas include all but two of the activity types analyzed: fencing and stream crossings to protect aquatic restoration projects, and piling and other structure removal. Projects that restore natural flooding and sediment deposition regimes include the majority of the aquatic organism passage and the in-channel, side-channel, and floodplain projects. In a natural or restored environment, seasonal flooding contributes to fine sediment deposits, which promote riparian growth of vegetation with propagules, seeds, and organic matter. The sediment amends soil physical function by increasing water-holding capacity and providing a substrate for seedlings to establish. Reestablishment of these processes allows soil hydrologic, biologic, and nutrient-cycling functions to be restored and maintained in these riparian areas (Gregory et al 1991; Poff et al 1997; Stromberg et al 2007; Tabacchi et al 1998). We anticipate that 1,110 individual aquatic organism passage and in-channel, side-channel and floodplain projects would be completed within a decade. Several acres of riparian habitat per project would have improved soil function as a result. For example, replacing an undersized culvert with a properly designed stream simulation structure will allow the passage of debris and flood flows to downstream reaches and restore soil functions in adjacent riparian floodplain soils. Approximately 18,295 acres of riparian soil function would be restored through these projects.

All the riparian vegetation projects would restore the natural vegetation dynamics into the riparian systems by removing overstocked vegetation using prescribed fire or mechanical methods, or restoring the natural vegetation structure and composition. Restoring the vegetation and natural disturbance mechanisms in riparian systems will also restore the biological and nutrient cycling functions of the soils (Tabacchi et al 1998). Soil biology and nutrient cycling is highly tied to the aboveground plant community and vegetation dynamics of a site. The soil environment is likely the most complex biological community on the planet. The belowground soil organism populations are closely tied to the vegetation found on the site. By restoring the aboveground vegetation, the belowground soil biology will result in improved biological and nutrient cycling functions (Barrios 2007; Bever et al 1997; Ettema 2002). Riparian vegetation projects would result in 4,053 acres of restored soil function in the riparian areas.

Nonsystem road decommissioning would have the largest beneficial impact on soil quality and productivity of all the activities. Nonsystem roads are typically severely compacted with limited soil functions and impaired soil productivity. Soil structure, water infiltration, aeration, root penetrability, and soil biological activity improvements are observed with road decommissioning techniques (Lloyd et al. 2013). Combined with a long-term reduction in erosion and mass wasting, an overall increase of soil quality and productivity can be attributed to road decommissioning (Foltz et al 2007; Grace and Clinton 2007; Switalski et al 2004). It is anticipated that 2,606 acres would be directly converted from nonproductive lands with permanent soil impairment to productive sites with restored soil function with over a decade of implementation.

Short-term detrimental soil conditions are anticipated to occur with all the activity types causing ground disturbance with heavy equipment or fire. These include all analyzed activities with the exception of beaver habitat restoration. Detrimental soil conditions include soil disturbance that results in a short-term impairment of soil productivity and function such as compaction, puddling, displacement, severely burned soils, and eroded sites.[1] These impacts are associated with the use of heavy machinery and fire (Page-Dumroese et al 2000; Reeves et al 2011, 2012). By following project design criteria, detrimental soil conditions should be limited to the footprint of the projects in both scope and scale. Within 10 years, projects across the region would have temporarily caused detrimental soil conditions on approximately 5,214 acres. Through restorative actions as required, these short-term impacts should be recovered within 15 years to productive sites from the time of project implementation (Fleming et al 2006; Lloyd et al 2013; Page-Dumroese et al 2006; Powers et al 2005; Tan et al 2005).

With most activity types, short-term detrimental soil conditions associated with ground-disturbing activities are likely to occur. All analyzed actions would make progress to improve soil functions in the riparian areas with nonsystem road decommissioning as the only proposed action that restores soils back into the productive land base from an impaired non-productive state. These long-term improvements in soil function are anticipated for approximately 25,357 acres or more within the region, approximately five times the amount of short-term detrimental soil conditions.

[1] FSM 2520 R6 Supplement 2500-98-1

Table 1. Improved soil function and detrimental soil conditions (DSC) by category and project type

Project category	Assumptions for improved function	Assumptions for Detrimental Soil Condition	Improved function (acres/ project)	Detrimental Soil Condition (acres per project)	No. of projects per decade	Soil function improved (acres)	Detrimental Soil Conditions (acres)
Aquatic Organism Passage	**no data**	**no data**	**no data**	**no data**	**350**	**403**	**158**
1. Fish Passage Restoration	1 acre downstream improved	staging area	1.0	0.3	333	333	83
2. Small Dam Removal (less than 10 ft. high; less than 15 acre ft.)	project footprint improved	project footprint + staging area	4.0	4.3	18	70	74
In-channel, Side-channel, Floodplains	**no data**	**no data**	**no data**	**no data**	**760**	**18,295**	**2,167**
3. Beaver Dam Analogues	project footprint improved	staging area	1.0	0.3	8	8	2
4. Bull Trout Protection	no impact	no impact	0.0	0.0	8	0	0
5. Channel Reconstruction/Relocation	project footprint improved	10% of project area + staging	12.5	1.5	38	477	57
6. Fencing & Stream Crossings to Protect Aquatic Restoration Projects	no impact	minimal impact	0.0	0.0	15	0	0
7. In-channel Nutrient Enhancement	no impact	no impact	0.0	0.0	8	0	0
8. Large Wood, Boulder, and Gravel Placement (does not include upland LWD acquisition)	project footprint improved	10% of project area + staging	29.6	3.2	532	15,767	1,710
9. Legacy Structure Removal	project footprint improved	project footprint + staging area	0.5	0.8	15	8	11
10. Off- and Side-Channel Habitat Restoration	project footprint improved	10% of project area + staging	8.7	1.1	38	332	43
11. Piling and other Structure Removal	no impact	staging area	0.0	0.3	8	0	2
12. Reduction and Rehabilitation of Recreation Impacts (does not include campground or trail relocation)	project footprint improved	project footprint + staging area	10.9	11.2	15	166	170
13. Set-back or Removal of Existing Berms, Dikes, and Levees	project footprint improved	10% of project area + staging	12.7	1.5	30	387	46
14. Streambank Restoration	project footprint improved	10% of project area + staging	25.3	2.8	46	1152	127
Riparian Vegetation	**no data**	**no data**	**no data**	**no data**	**210**	**4,053**	**163**
15. Beaver Habitat Restoration	project footprint improved	minimal impact	1.0	0.0	11	11	0

Project category	Assumptions for improved function	Assumptions for Detrimental Soil Condition	Improved function (acres/ project)	Detrimental Soil Condition (acres per project)	No. of projects per decade	Soil function improved (acres)	Detrimental Soil Conditions (acres)
16. Juniper Removal	project footprint improved	5% of project area	10.0	0.5	11	105	5
17. Riparian Vegetative Planting	project footprint improved	minimal impact	5.0	0.0	158	788	0
18. Riparian Vegetation Treatment & Controlled Burning	project footprint improved	5% of project area	100.0	5.0	32	3150	158
Road Decommissioning	**no data**	**no data**	**no data**	**no data**	**480**	**2,606**	**2,726**
19. Non-System Road Decommissioning	project footprint improved	project footprint + staging area	5.4	5.7	480	2,606	2,726
Totals	**no data**	**no data**	**no data**	**no data**	**no data**	**25,357**	**5,214**

* Assumptions and rationale found in the methodology section.

Cumulative Effects

Analysis of the proposed actions meet Forest Service policy and direction as soils should not have permanent and substantial impairment as a result of cumulative effects from past, ongoing and future actions. Detrimental soil conditions generated from proposed management activities would not exceed regional thresholds used to indicate potential impairments to soil productivity.[2] Actions taken for aquatic restoration would alleviate legacy impacts from past management as described in the direct and indirect effects section. However, not all of the disturbed sites across the landscape in riparian areas would be restored as a result of this proposal. Ongoing and foreseeable actions within the proposed activity areas consist of additional watershed improvement projects as well as recreation, grazing, mining, and forest thinning. As described above, these restoration projects often include a short-term effect offset by a long-term benefit. Considering the limited degree and geographic extent of these short-term detrimental effects occurring during project implementation, and how they are offset by the long-term benefits of the projects, cumulative effects are unlikely to occur with the implementation of this decision. Though difficult to determine measurably, the actions would improve site conditions as compared to existing conditions. There is potential to have cumulative detrimental soil impacts from livestock grazing and mining projects occurring in riparian areas. The primary soil disturbance mechanisms from livestock grazing is hoof action causing compaction and streambank erosion. Mining results in loss of soil productivity from displacement and removal of soil horizons. In the cases where aquatic restoration actions overlap in time and space with livestock grazing and mining, the restorative nature of the projects may be limited and additional recovery time may be needed for detrimental soil disturbance to recover.

Consistency Statement

The proposed EA complies with the following direction guiding soil management:

The Multiple-Use Sustained-Yield Act of 1960 - This act established that the sustained yield of goods and services must be conducted without resulting in permanent impairment of the productivity of the land.

National Forest Management Act of October 22, 1976 - The National Forest Management Act reorganized, expanded, and otherwise amended the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for the management of renewable resources on National Forest System lands without causing irreversible damage to soil, slope and watershed conditions.

Region 6 Soil Quality Direction (FSM 2520 R6 Supplement 2500-98-1) – The manual direction states to manage National Forest System lands under ecosystem management principles without permanent impairment of land productivity and to maintain or improve soil and water quality.

[2] FSM 2520 R6 Supplement 2500-98-1

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