SOILS

INTRODUCTION
This section discloses the results of the soils resource analysis in the Helwick Project Area on soil productivity. Field surveys for this project were conducted in 2014 using the R1 Soils Protocol (USDA FS 2011a).

Regulatory Framework
The regulatory framework pertaining to soils is summarized below. For additional information, please refer to the Soil and Water Regulatory Framework in the Soil and Water Project File.

STATE AND FEDERAL LAWS AND REGULATIONS

The regulatory framework providing direction for protecting a site's inherent capacity to grow vegetation comes from the following principle sources:

- *The Multiple Use-Sustained Yield Act of 1960* – Federal law
- *The Forest Plan and Regional Soil Quality standards (2554.03-R1 Suppl. 2500-99-1)*
- *Soil and Water Conservation Practices Handbook (FSH 2509.22 R-1/R-4 Amendment No. 1 Effective 5/88)*
- *The 2015 Kootenai Forest Plan (USDA FS 2015a, 22015b)*

The Multiple Use-Sustained Yield Act of 1960 directs the Forest Service to achieve and maintain outputs of various renewable resources in perpetuity without permanent impairment of the land's productivity.

Section 6 of the National Forest Management Act of 1976 (NFMA) – Section 6(g)(3) states that harvest shall be “carried out in a manner that is consistent with the protection of soil resources” and that “soil, slope, or other watershed conditions will not be irreversibly damaged”. To comply with NFMA, the Chief of the Forest Service has charged each Forest Service Region with developing soil quality standards for detecting soil disturbance and indicating a loss in long-term productive potential.

The Regional Soil Quality Standards (R-1 Supplement 2500-99-1) provides soil quality standards to assure the statutory requirements of NFMA are met. Manual direction recommends maintaining 85% of an activity area’s soil at an acceptable productivity potential with respect to detrimental impacts, including the effects of compaction, displacement, rutting, severe burning, surface erosion, loss of surface organic matter, and soil mass movement. This recommendation is based on research indicating that a decline in productivity would have to be at least 15% to be detectable (Powers, 1990). In areas where more than 15 percent detrimental soil conditions exists from prior activities, the cumulative detrimental effects from project implementation and restoration should not exceed the conditions prior to the planned activity and should move toward a net improvement in soil quality. These standards do not apply to intensively developed sites such as permanent roads/landings, mines, developed recreation and administrative sites because they have been removed from the productive land base.

The Forest Plan states that project-specific best management practices (BMPs) will be incorporated into all land use and project plans as a principle mechanism for controlling non-point pollution sources (FW-GDL-WTR-03). Best Management Practices consist of state-of-the art soil and water conservation practices (SWCPs) as outlined in Water Conservation Practices Handbook R-1/R-4 Amendment No. 1 (FSH 2509.22) and designed to minimize soil disturbance during harvest and road construction activities.
Soils

The 2015 Forest Plan states that management practices will rely on a variety of passive and active management techniques to trend towards desired conditions for vegetation and soil restoration. Below is a listing of the 2015 Forest Plan goals, desired conditions, objectives, and guidelines for the soil resource which apply to the Helwick Project Area. These resource indicators will be used to track and measure potential effects of the proposed Helwick Project Area.

Table S-1: Resource Indicators and Measures for Assessing Effects (USDA FS 2015b)

<table>
<thead>
<tr>
<th>Resource Elements</th>
<th>Resource Indicators</th>
<th>Measure (Quantify if possible)</th>
<th>Used to address: P/N or key issue?</th>
<th>Source (FP component, law or policy, BMPs, etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Soil Goals</td>
<td>Maintain soil productivity and ecological processes where functioning properly, and restore where currently degraded. Maintain the physical, chemical, and biological properties of soils to support desired vegetation conditions and soil-hydrologic functions and processes within watersheds. Forest</td>
<td>Detrimental Soil Disturbance Values</td>
<td>Y</td>
<td>GOAL-SOIL-01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R-1 Supplement No. 2500-99-1</td>
</tr>
<tr>
<td>Forest Desired Conditions</td>
<td>Soil organic matter, physical conditions, and down woody debris maintain soil productivity and hydrologic function. Physical, biological, and chemical properties of soils are within the recommended levels by soil type as described in the KNF soil inventory. These soil properties enhance nutrient cycling; maintain the role of carbon storage, and support soil microbial and biochemical processes.</td>
<td>Tons per acre measured CWD</td>
<td>Y</td>
<td>FW-DC-SOIL-01; FW-DC-VEG-08</td>
</tr>
<tr>
<td>Forest Desired Conditions</td>
<td>Areas with sensitive and highly erodible soils or landtypes with mass failure are not destabilized as a result of management activities.</td>
<td>Acres proposed harvest on landtypes of concern</td>
<td>Y</td>
<td>FW-DC-SOIL-02</td>
</tr>
<tr>
<td>Forest Desired Conditions and Guidelines</td>
<td>Soil impacts are minimized and previously activity areas that have incurred detrimental soil disturbance recover through natural processes and/or restoration activities. Organic matter and woody debris, including large diameter logs, tops, limbs, and fine woody debris, remain on site after vegetation treatments in sufficient quantities to retain moisture, maintain soil quality, and enhance soil development and fertility by periodic release of nutrients as they decompose.</td>
<td>Tons per acre CWD to be retained at the individual unit level</td>
<td>Y</td>
<td>FW-DC-SOIL-03; FW-GDL-VEG-03</td>
</tr>
<tr>
<td>Forest Desired Conditions</td>
<td>Soil organic matter and down woody debris support healthy micorrhizal populations, protects soil from erosion due to surface runoff, and Detrimental Soil Disturbance values at the proposed harvest unit level</td>
<td></td>
<td>Y</td>
<td>FW-DC-SOIL-04</td>
</tr>
<tr>
<td>Resource Elements</td>
<td>Resource Indicators</td>
<td>Measure (Quantify if possible)</td>
<td>Used to address: P/N or key issue?</td>
<td>Source (FP component, law or policy, BMPs, etc)</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Forest Objectives</td>
<td>Over the life of the Plan, initiate restoration of 75 to 150 acres not meeting soil quality criteria.</td>
<td>Post-harvest proposed soil restoration activities</td>
<td>Y</td>
<td>FW-OBJ-SOIL-01; Specifically Unit 10 which is projected to potentially exceed 15% soil disturbance.</td>
</tr>
<tr>
<td>Forest Guidelines</td>
<td>Ground-based equipment should only operate on slopes less than 40 percent, in order to avoid detrimental soil disturbance. Where slopes within an activity area contain short pitches greater than 40 percent, but less than 150 feet in length, ground-based equipment may be allowed, as designated by the timber sale administrator.</td>
<td>Acres proposed harvest on slopes exceeding 40% where ground based operations are proposed</td>
<td>Y</td>
<td>FW-GDL-SOIL-01; State of Montana BMPS Section IV.B</td>
</tr>
<tr>
<td>Forest Guidelines</td>
<td>Coarse woody debris is retained following vegetation management activities per (FW-GDL-VEG-03).</td>
<td>Tons per acre CWD to be retained at the individual unit level</td>
<td>Y</td>
<td>FW-GDL-SOIL-02 FW-GDL-VEG-03</td>
</tr>
<tr>
<td>Forest Guidelines</td>
<td>On nutrient-limited landtypes, harvesting organics should remain on site for at least 6 months or over a winter season to allow foliage nutrients to leach into the soil, except where site-specific analysis indicates the fuels would present an unacceptable hazard.</td>
<td>Acres of nutrient limited landtypes proposed per harvest by Alternative</td>
<td>Y</td>
<td>FW-GDL-SOIL-03</td>
</tr>
<tr>
<td>Forest Guidelines</td>
<td>Project specific best management practices (BMPs) should be incorporated into all land management activities as a principle mechanism for protecting soil resources</td>
<td>Acres proposed harvest in the Helwick Project Area requiring BMPs to meet Montana State Soil Requirements</td>
<td>Y</td>
<td>FW-GDL-SOIL-05</td>
</tr>
</tbody>
</table>

**ANALYSIS AREA AND METHODS**

**SOILS ANALYSIS AREA**
Soils are the basic support system of forest ecosystems, providing nutrients, water, oxygen, heat, and mechanical support to vegetation. Any environmental stressor that alters the natural function of the soil has the potential to influence the productivity, species composition, and hydrology of forest systems. Maintenance of soil quality is dependent upon the protection of surface layers from erosion, displacement, and compaction, as well as the
continual cycling of nutrients and organic material. Soil quality refers to the capacity of a soil to function within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality, and promote plant and animal health. Various factors influence soil quality. Although management activities do not affect factors such as climate and soil parent material, they can affect physical, chemical, biologic, and hydrologic soil properties.

The direct and indirect effects of the alternatives will focus on individual soils analysis areas as defined by the Forest Service Manual (R-1 Supplement No. 2500-99-1):

“Analysis Area: A soils analysis area is a discrete land area affected by management activity to which soil quality standards are applied. Activity areas must be feasible to monitor and include harvest units within timber sale areas, prescribed burn areas, and grazing areas or pastures with range allotments. All proposed temporary roads, landings and skid trails associated with proposed harvest areas are included within the analysis area.

The proposed soil analysis area for this project involves stand improvements, timber harvest, piling, fuel treatments, fire line construction, skid trails, landings, weed spraying, both new and temporary road construction, and road decommissioning and storage, and post-harvest activities. System roads are not a part of the soils analysis areas.

ANALYSIS METHODS

Existing Condition
Existing condition for the soils resource were determined using timber stand records, GIS data, and on-the ground visits. Landtypes and hazard ratings were gathered from landtype descriptions and characteristics found in the Soil Survey of Kootenai National Forest Area, Montana and Idaho (Kuennen and Gerhardt 1995).

All units containing evidence of existing soil disturbance related to past management activities received a full qualitative field survey using R1 Soil Survey Procedures. Field soil surveys consisted of random stratified transect/sample point methods with confidence intervals at or above 80% ± 5% with the majority of surveys being 95% ± 5%. Completed soil surveys can be found in the Soil Project File and/or District Files. Existing detrimental soil disturbance numbers are a result of all currently measureable effects of past actions in each activity area, including but not limited to: timber harvest (trails and landings), temporary road construction, management related burns, grazing, off highway vehicles (ATV’s), natural disturbances, firewood gathering, etc. These methods provide data that is used in the analysis to determine if Forest Plan and Regional Soil Quality Standards would be met.

Field Sampling Procedure
In order to determine the severity and aerial extent of existing soil disturbance from previous forest management activities, randomly selected soil transects were conducted across representative portions of the proposed activity areas (proposed harvest polygons, temporary roads, and landings). Every other step is considered a sample location and sampled using common tile spade shovel to determine the resistance of penetrating into the soil. Physical resistance to penetration was found to correlate quite well with altered soil conditions related with past management activity. In areas with the greatest soil compaction due to past management activities the shovel blade is only capable of penetrating a short distance into the soil and with great effort.

Field sampled transect points were placed in one of three categories: 1) no disturbance; 2) disturbance present but not detrimental; and 3) detrimental soil disturbance (DSD). The detrimental disturbance category is considered detrimental as defined in FSM 2550 and Region 1 Supplement 2500-99-1. As a result, DSD is defined as the proportion of an activity area that may be subject to displacement, compaction, rutting, erosion, or
Detrimental Soil Disturbance (DSD)
The soils in an activity area are considered detrimentally disturbed at a given sample point when one or a combination of any of the attributes listed below is present due to past Forest Management activities:

a) **Compaction:** a 15% increase in natural bulk density. Soil compaction reduces the supply of air, water, and nutrients to plants. Roading, ground based yarding, dozer and grapple piling activities are the major contributors to compaction.

b) **Soil ruts:** Machine-generated soil displacement having smeared the soil surface in a rut. Wheel ruts at least 2 inches deep in wet soils.

c) **Displacement:** removal of one inch or more surface soil continuous area greater than 100 sq. feet which often consists of the O and A soil horizons. Displacement removes the most productive part of the soil resource. Temporary roads, skid trails, ground-based yarding, dozer piling and cable corridors are the major contributors to displacement.

d) **Surface erosion:** Indicated by rills, gullies, pedestals, and localized soil deposition.

e) **Severely burned soils:** Physical and biological changes to the soil resulting from high-intensity burns of long duration as described in the Burned Area Emergency Rehabilitation Handbook (USDA FS 1995a - FSH 2509.13).

f) **Soil mass movement:** any soil mass movement caused by management activity.

Detrimental Soil Disturbance

**Direct and Indirect Effects**
The predicted detrimental soil disturbance (DSD) values were calculated based on a summation of past monitoring of soil productivity (KNF 1988-present date) within the Kootenai National Forest (Soils Table 3-2). The percentages were developed as the average soil disturbance level equated to harvest equipment type, fuel treatment methods, and season of operation as calculated from soil monitoring data collected (2000-2005). Timber removal had always occurred prior to the “post-harvest field surveys” and includes mechanical fuel abatement activities such as excavator piling activity if present. The end DSD figure is a compilation of all measured disturbance values and does not separate each category of disturbance where present within a unit. Thus, the value of 8% DSD for summer tractor is a “statistical summary” which takes into account not only the skid trails but temporary roads, mechanized piling, and fire lines if present within the units being surveyed at that time and date. New temporary roads are considered detrimentally disturbed through removal of organic matter, displacement, and/or compaction. Re-opening of an existing temporary road prism is considered to have 0% additional detrimental disturbance as such roads are considered to be disturbed for greater than 50 years. Temporary roads yield an average of 2 acres of DSD per mile of road. Refer to Soils Table S-2.
Table S-2. Monitoring Results of Detrimental Soil Disturbance from Management Activities on the Kootenai National Forest (Kuennen 2006a)

<table>
<thead>
<tr>
<th>Category</th>
<th>Season of Operation</th>
<th>Detrimental Disturbance Coefficients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skyline</td>
<td>NA</td>
<td>1</td>
</tr>
<tr>
<td>Tractor</td>
<td>Summer</td>
<td>8</td>
</tr>
<tr>
<td>Tractor</td>
<td>Winter</td>
<td>4</td>
</tr>
<tr>
<td>Forwarder</td>
<td>Summer</td>
<td>4</td>
</tr>
<tr>
<td>Forwarder</td>
<td>Winter</td>
<td>2</td>
</tr>
<tr>
<td>Feller Buncher</td>
<td>NA</td>
<td>2</td>
</tr>
<tr>
<td>Helicopter</td>
<td>NA</td>
<td>0</td>
</tr>
<tr>
<td>Excavator Piling</td>
<td>NA</td>
<td>2</td>
</tr>
<tr>
<td>Fire line Construction</td>
<td>NA</td>
<td>1</td>
</tr>
<tr>
<td>Grazing</td>
<td>NA</td>
<td>2</td>
</tr>
<tr>
<td>Tractor secondary entry</td>
<td>Summer</td>
<td>4</td>
</tr>
<tr>
<td>Tractor secondary entry</td>
<td>Winter</td>
<td>2</td>
</tr>
<tr>
<td>Forwarder secondary entry</td>
<td>Summer</td>
<td>2</td>
</tr>
<tr>
<td>Forwarder secondary entry</td>
<td>Winter</td>
<td>1</td>
</tr>
</tbody>
</table>

1 DSD percent is not necessarily additive to other activities. This is because the percentages presented for each management activity included some units with excavator piling, fire line construction, and/or grazing in the data set. In addition, disturbance from these activities within harvest units usually overlaps at least a portion of the skidding disturbance.

2 The numbers for this document were based on percentages from the last 5 years. Previous documents have used 18 year averages. Typically the larger data set is more accurate, but because the 18 year data set included practices that are not used anymore (i.e. dozer piling) it was deemed more appropriate to use the more accurate information pertaining to modern harvest and slash disposal methods.

3 Feller buncher must be operated straight up and down the fall line on slopes not exceeding 45%. Where such activities occur on skyline harvest units an additional 2% DSD is expected to occur.

4 Fire line construction prior to 1995 included dozer activity while data collected following 1995 generally included handline construction or excavator bucket-width activity. As a result there has been a significant reduction of fire line disturbance in a given unit.

5 In proposed secondary entry harvest units which currently are equivalent or exceed 8% DSD, the proposed ground based harvest activities are estimated as having approximately a 50% disturbance value compared to similar harvest activities in currently undisturbed soils (Louis Kuennen pers. comm. 2011). This reduction in the anticipated DSD values only applies to ground based harvest operations. It is assumed that units containing less than 8% DSD are more historic in nature and are on a recovery trend as displayed by revegetation of historic skid trails and second-growth stand conditions.

Generally, detrimental impacts on soils are not permanent and depend primarily on soil texture, parent material, aspect, and level of disturbance, i.e. compaction. Soil recovery begins once activities cease on the site (Kuennen 2006b). However, vegetative recovery time may take approximately 30 to 70 years as the second growth timber becomes established in and around the disturbed areas (Dykstra and Curran 2002; Froehlich and McNabb 1983; Froehlich and others 1983 and 1985). In areas where soil displacement mixes or moves the volcanic ash surface layer and reduces moisture holding capacity and productivity may continue to be impacted far beyond the 70-year timeframe.

Indirect effects may include the reduction of site productivity due to the removal of vegetation and nutrients. Large woody debris (woody residue >3” diameter) and finer organic material are essential for maintenance of sufficient microorganism populations and long-term site productivity. Design features (see Design Criteria) are incorporated into the activities to manage large woody debris and organic matter as detailed in the research guidelines contained in Graham and others (1994). Where feasible, smaller woody material such as tree tops,
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Foliage, and branches would be left to over-winter before fuels treatment, which allows nutrients to leach out of these materials and into the soil (FW-DC-SOIL-03).

**Cumulative Effects**

Cumulative effects include the combination of direct and indirect effects from past, present, and reasonably foreseeable activities. Direct, indirect, and cumulative effects on soils are measured within each activity area. Existing system roads and designated landings on the National Forest transportation system are considered dedicated lands and are not part of the cumulative effects.

**ASSUMPTIONS AND LIMITATIONS**

The potential detrimental disturbance numbers for each proposed harvest unit are based on empirically derived coefficients that were obtained and averaged from numerous monitored sites throughout the Kootenai National Forest (Kuennen 2006a and 2003). The assumptions are limited to the harvest and slash disposal methods for which coefficients have been determined, and its coefficients assume that Best Management Practices (BMPs) will be implemented. The predicted values do not account for changes in soil type, the recovery of soils over time, or existing conditions.

Evaluation of cumulative effects to soil productivity are analyzed for activity areas as opposed to the integrated “watershed scale” because that is not considered an appropriate geographic area. Soil conditions are site-specific. Loss of soil productivity in one treatment unit will not lead to a loss in soil productivity in an adjacent stand. Soil productivity can vary from one square foot to the next with each area functioning independently. Thus, the highly variable and independent nature of soil productivity requires site-specific analyses to maintain the proper context. Assessments of cumulative effects on soil productivity is retained at the site-specific boundary scale since analysis at the watershed scale for soils misrepresent management activity effects by masking and/or diluting site-specific effects across a larger area. In contrast, soil processes such as erosion regime and hydrologic functions occur at a watershed scale and can be analyzed as such in Water Resource Reports.

**SCIENTIFIC UNCERTAINTY AND CONTROVERSY**

Soil productivity relies on complex chemical, physical, and climatic factors that interact within a biological framework. For any given site and soil, a change in a key soil variable (i.e. bulk density, soil loss, nutrient availability, etc.) can lead to changes in potential soil productivity. The intent is to prevent extensive detrimental soil disturbance that would result in a measurable decline in timber productivity for a site. The Region 1 supplement requires that detrimental soil disturbance should be limited to 15% of an activity area. The 15% value is based on the assumption that soil quality and productivity will be maintained if less than 15% of an activity area is detrimentally impacted after disturbance (Page-Dumroese et al. 2000).

Currently the effects of soil disturbance on soil quality are being studied across North America by a cooperative research project called the North American Long Term Soil Productivity Study (LTSP). The study began in 1990 and is currently ongoing in order to provide the best available science to forest managers. Results over the past 10 years indicate that there is little evidence of adverse effects of surface organic removal or soil compaction on productivity as measured by total biomass production, and the growth and vigor of planted trees (Powers et al. 2004).

Between 2012-2013 the KNF initiated a 2-year study to determine soil recovery in timber sale units initially monitored following harvest activities between 1992-2006. This study involved re-sampled 87 Timber Sales which involving 183 timber sale units and 5,706 timber harvest acres. Secondary sampling involved collected
Soils

Soils information from 385 transects and 76,561 data points in harvest areas which had been previously monitored for soil disturbance. Information showed that of the units sampled 86% displayed reduced detrimental soil disturbance values as compared to the originally sampled values and is thought to primarily be based on soil freeze-thaw and vegetative relationships. All units were re-sampled at a 95% confidence (Gier and Kuennen 2013; Gier et al 2013a, 2013b). Results of this study indicate past activities were consistent with the 2015 Forest Plan guidelines FW-GDL-SOIL-01; FW-GDL-SOIL-02; FW-GDL-SOIL-04 and FW-GDL-SOIL-05.

Additional controversy surrounds the use of the term ‘irreversible’ in the NFMA. The NFMA directs forest management to “insure that timber will be harvested from NFS lands only where soil, slope, or other watershed conditions will not be irreversibly damaged.” The detrimental soil disturbance described in this analysis does not necessarily indicate permanent or irreversible damage. Detrimental soil damage is reversible if the processes (organic matter, moisture, top soil retention, soil organisms) are in place and time is allowed for recovery.

AFFECTED ENVIRONMENT

SOIL REFERENCE CONDITIONS

The bedrock underlying the project area is composed mostly of metamorphosed sediments of ancient sea beds from the Precambrian era (0.8-1.4 billion years before present), referred to as the Belt Supergroup. The major structural feature is the Hope Fault, which parallels the Clark Fork valley, and several large northwest-trending faults that are perpendicular to the drainage.

The project area is composed of an erosional landscape modified by some alpine glaciation (approximately the upper 1/4 of the drainage). The landform is very steep, except for the valley floor adjacent to the Clark Fork River. The lower elevations were impacted by episodic Glacial Lake Missoula ice damming activities which came down the Purcell Trench from the north, and extended eastward up the Clark Fork valley. This large glacial lake reached an average water line level of 4,200 feet.

Most soils in the Helwick project area are residual which means that they were not affected by glaciation and developed “in place” rather than by glacial activities. The amount of rock present in residual soils is much higher than that associated with glacial till or Cordilleran Ice Sheet soils and rock shape is strongly angular.

According to Zdanowicz and others (1999) approximately 7,700 years ago Mt. Mazama erupted in southwest Oregon and deposited a layer of volcanic ash-influenced loess over northwestern Montana forming a topsoil horizon in many local areas. This layer is present on all northerly and easterly aspects and the higher elevations of the southerly and westerly aspects and is important since it increases soil productivity and provides the best rooting environment within the soil profile. The ash cap is light weight and feathery and has a yellowish to reddish brown color ranging from four to 14 inches thick. The uppermost ash is usually enriched with organic matter and has been incorporated into the local soil system. These ash cap soils have a high water-nutrient holding capacity and are important for soil productivity. Generally speaking the sub-soil horizons are not nearly as fertile as the surface horizons.

Between the eruptions of Mt. Mazama to the early 1900s, the soils were relatively undisturbed. Naturally occurring surface erosion and small-scale landslides probably occurred on occasion, but the overall magnitude would have been insignificant in terms of long-term soil productivity. Soil recovery in such areas was attained when the slope reached a stable angle and/or the area was vegetated. Soil productivity was maintained over the long-term as vegetative matter slowly decomposed or burned in low-intensity natural wildfires.
Historically, the most prevalent large-scale disturbance in the project area was wildfire. Stand replacing fires varied in frequency from 50-350 years, depending on vegetation type and location. Once fire passed through an area, erosion increased, especially on steep slopes and in headwater swales where most vegetation was removed, until sufficient forest floor and canopy vegetation had recovered. More frequent, low-intensity under burns likely had little effect on soils due to the short contact time and lower temperatures associated with these fires.

EXISTING CONDITION

Existing condition is the result of the past management activities (temporary road construction, timber harvest, prescribed burning, etc.) and natural events (wildfire, floods, landslides, etc.) that occurred in the analysis area. These activities and events provide baseline conditions for the affected environment in the analysis area.

Three criteria were used to assess existing condition in the analysis area for soil resources:

- Kootenai National Forest Landtypes;
- Identification of Sensitive Soils; and
- Coarse Woody Debris

LANDTYPES

There are 50 recognized landtypes on the KNF. This classification of landtypes is based on: landforms, geology, soils, vegetation, climate, and drainage type. They describe inherent conditions and do not change as a result of management. The landtypes were compiled in Kuennen and Nielson-Gerhardt (1984), and published in Soil Survey of Kootenai National Forest Area, Montana and Idaho (Kuennen and Nielson-Gerhardt 1995). Landtype classification helps determine suitability, equipment operating limitations, and the production potential of the landscape. It is an important tool for protecting soils during resource management activities. Refer to Figure S-1: Landtypes in the Helwick analysis area. The landtype map is generally quite accurate; however, field verification may indicate some site variability. The landtypes were broken down into five generalized groupings or series which include the following:

- **Water influenced Landtypes (100 Series):** Such landtypes are located in very low relief topography which is highly water influenced.
- **Steep topography Landtypes (200 Series):** These landtypes exist in very steep topographic lands (60% plus). Such landform areas are usually rocky slopes and may be convex or linear in shape.
- **Glaciated Landtypes (300 Series):** These landtypes are located in areas of past glacial deposits and shaped through time by several glacial advances that occurred throughout the Kootenai National Forest. The most recent, the Cordilleran Ice Sheet, retreated from the area several thousand years before present. These landtypes included glaciated slopes, drumlins, and moraines.
- **Alpine till Landtypes (400 Series):** These landtypes exist in very steep alpine or subalpine locations and consist of glacial cirque headwalls and trough walls.
- **Mid-elevation Landtypes (500 Series):** These landtypes are residual in nature and developed on site and are typically mid-slope in elevation.
Figure S-1. Landtypes of the Helwick Analysis Area

Of the 50 recognized landtypes on the KNF 11 of these landtypes are found in the Helwick project area (Soils Figure S-1, Soils Table S-3). Within these landtypes, only 7 have proposed harvest and/or fuel activities under the proposed action. Management activities on each landtype are designed to be comparable to the risk associated with the landtype. Different landtypes have differing risks associated with harvest and/or road construction activities. The landtypes in the analysis area and their implications are displayed in Soils Table S-3. It should be noted that such risks are often mitigated by BMPs during timber harvest activities.

Table S-3. Landtypes in the Analysis Area (Kuennen and Gerhardt 1995)

<table>
<thead>
<tr>
<th>Landtype</th>
<th>Acres</th>
<th>Timber Management</th>
<th>Road Construction/Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tractor Operations</td>
<td>Sediment Hazard</td>
</tr>
<tr>
<td>101²</td>
<td>427</td>
<td>Soil Damage</td>
<td>Severe</td>
</tr>
<tr>
<td>251²</td>
<td>141</td>
<td>Slope, Rock</td>
<td>Severe</td>
</tr>
<tr>
<td>360²</td>
<td>211</td>
<td>Rock</td>
<td>Slight</td>
</tr>
<tr>
<td>405²</td>
<td>83</td>
<td>Slope</td>
<td>Moderate</td>
</tr>
<tr>
<td>406</td>
<td>330</td>
<td>Slope</td>
<td>Moderate</td>
</tr>
<tr>
<td>Landtype</td>
<td>Acres</td>
<td>Timber Management</td>
<td>Road Construction/Maintenance</td>
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<tr>
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<td>-------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tractor Operations</td>
<td>Sediment Hazard</td>
</tr>
<tr>
<td>407²</td>
<td>343</td>
<td>Soil Damage</td>
<td>Severe</td>
</tr>
<tr>
<td>502²</td>
<td>162</td>
<td>Slope</td>
<td>Slight</td>
</tr>
<tr>
<td>503²</td>
<td>564</td>
<td>Slope, Rock</td>
<td>Slight</td>
</tr>
<tr>
<td>552²</td>
<td>250</td>
<td>Slope¹</td>
<td>Moderate¹</td>
</tr>
<tr>
<td>555²</td>
<td>3,405</td>
<td>Complex slope, Soil Damage, Rock</td>
<td>Moderate</td>
</tr>
<tr>
<td>570²</td>
<td>1,459</td>
<td>Slope</td>
<td>Severe</td>
</tr>
<tr>
<td>Total Acres</td>
<td>9,187</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Not applicable due to such landtypes only having only scattered stands of trees.
² Landtypes present within proposed harvest units.

**SENSITIVE SOILS**

Sensitive soils are identified based on one of three characteristics: 1) landtypes of concern, 2) riparian/wetland areas; and 3) low productivity soils. Sensitive soils comprise 413 acres or 5 percent of the entire project area. Sensitive soils are best addressed through avoidance, best management practices (BMPs), buffers, and/or through design criteria.

**Landtypes of Concern**

There are seven designated “landtypes of concern” on the KNF that should be given additional consideration prior to the introduction of management activities. These are landtypes 102, 112, 325, 351, 365, 370, and 520 (Kuennen 2006c). When viewed at the project area, level no landtypes of concern are present. As a result no landtypes of concern are present at the individual unit level.

**Riparian/Wetland Areas**

There are scattered riparian corridors and small patches of wetland areas in the project area. Riparian and wetland soils are considered sensitive because their moisture levels are high all or most of the year, and moist soils are more prone to compaction, displacement, rutting, and puddling. Harvest and road construction activities will avoid timber activity in wetland areas (FW-GDL-RIP-05).

**2015 Forest Plan riparian area direction:** Riparian management direction describes Riparian Habitat Conservation Areas (RHCAs) are based on direction laid out by the Inland Native Fish Strategy (USDA Forest Service 1995b) (INFS) and include areas of specified widths that surround stream channels, riparian areas, and wetlands. By definition, RHCAs are more extensive than the riparian and wetland features they protect (see “Water Resources” Section). RHCAs cannot be reduced to less than the SMZ boundary width required by law. As a result, one indirect effect to riparian areas and wetlands could be an increase in blow down trees or additional large woody debris from opening the stands in and around wet areas.
Soils

Low Productivity Soils

Soil productivity as defined by Brady and Weil (2002) is “the capacity of a soil for producing a specific plant or sequence of plants under a specified system of management.” The most productive part of the soil occurs near the surface, at the contact between the forest litter and the mineral soil. Here the litter has been decomposed into an organic rich layer containing most of the soil nitrogen, potassium, and mycorrhizae that must be present for a site to be productive. However, this is also the part of the soil that is easiest to disturb by management activities. Soil productivity levels for each landtype on the KNF are classified as low, moderate, or high in Kuennen and Gerhardt (1995). It is important to look at soil productivity to properly assess the effects of potential actions on a specific area. For instance, if timber harvest is proposed on a given area of land that was considered as having low soil productivity, additional actions may need to be taken to insure a fully stocked stand after harvest. Table S-4 displays the soil productivity by landtype in the Helwick project area.

Table S-4. Soil Productivity in the Helwick Project Area (Kuennen and Gerhardt, 1984)

<table>
<thead>
<tr>
<th>Landtype</th>
<th>Acres</th>
<th>Associated Biophysical Settings</th>
<th>Relative Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>101(^2)</td>
<td>427</td>
<td>Moist, Mixed Forest</td>
<td>High</td>
</tr>
<tr>
<td>251</td>
<td>141</td>
<td>Open-grown Forest</td>
<td>Moderate</td>
</tr>
<tr>
<td>360(^12)</td>
<td>83</td>
<td>Sub-alpine Forest</td>
<td>Low</td>
</tr>
<tr>
<td>405(^12)</td>
<td>330</td>
<td>Sub-alpine Forest</td>
<td>Low</td>
</tr>
<tr>
<td>406</td>
<td>343</td>
<td>Sub-alpine Forest</td>
<td>Moderate</td>
</tr>
<tr>
<td>407</td>
<td>162</td>
<td>Sub-alpine Forest</td>
<td>Moderate</td>
</tr>
<tr>
<td>502(^2)</td>
<td>564</td>
<td>Sub-alpine Forest</td>
<td>Moderate</td>
</tr>
<tr>
<td>503(^12)</td>
<td>250</td>
<td>Sub-alpine Forest</td>
<td>High</td>
</tr>
<tr>
<td>552(^2)</td>
<td>3,405</td>
<td>Moist, Mixed Forest</td>
<td>High</td>
</tr>
<tr>
<td>555(^2)</td>
<td>1,459</td>
<td>Sub-alpine Forest</td>
<td>High</td>
</tr>
<tr>
<td>570</td>
<td>2,022</td>
<td>Moist, Mixed Forest</td>
<td>High</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9,187</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Not applicable due to landtypes having only scattered stands of trees
\(^2\) Landtypes present in the Soils analysis area scale

Of the 11 landtypes within the project area, seven have proposed harvest and/or prescription burn activities under the proposed action alternative and are thus included as being in the soils analysis area. These are landtypes 251, 407, 502, 503, 552, 555, and 570. The majority of the project area has moderate to high soil productivity. Landtypes 360 and 405 are both rated as having low soil productivity and are located in the Soils analysis area. This equates to 413 acres or 5 percent of the soils analysis area having low productivity. When viewed at the project area level no harvest is proposed on low productivity landtypes. Application of project specific (BMPs) such as avoiding timber harvest in wet seasons (FW-GDL-RIP-05), maintaining buffer zones below open slopes, and skidding over snow or frozen ground will decrease the potential negative impacts to soil productivity regardless of landtype conditions.

SITE CONDITIONS IN THE ACTIVITY AREAS

Site conditions are considered for each activity area in the effects analysis portion of this assessment. Past activities affecting soils include, but are not limited to, road construction, timber harvest (including skid trails and landings), prescribed or natural wildfire, firewood gathering, and off-road vehicle use (OHVs). Percent
detrimental soil disturbance is defined by agency directives for Soil Quality Monitoring found in FSM R-1 Supplement No. 2500-99-1. The following are the categories of determining disturbed soils identified in FSM R-1 Supplement No. 2500-99-1: Compaction, Rutting, Displacement, Surface Erosion, Severely Burned Soils, and Mass Movement (Landslides). All types of detrimental soil disturbance will be considered in the examination of the existing condition and analysis of the environmental effects.

The three factors which have created the most impacts to soil conditions associated with the analysis area are:
- Road Construction
- Timber Harvest
- Fire

Road Construction

Common impacts to soils from road construction are displacement, compaction, and erosion (road-related runoff). Road construction affects soils by displacing topsoil layers from the road prism and compacting the road surface and shoulders. The road surface will not support trees and other forest vegetation as long as the road is used and maintained. Trees and shrubs will grow along the road bank, but site productivity is less than in unaffected soils in similar productivity zones.

Roads also disrupt hydrologic processes that occur within the soil profile. The cut slope intercepts subsurface flow and the compacted road surface reduces precipitation infiltration. As long as roads remain on the landscape, the impacts to soils persist. When road use ceases, soils gradually begin to recover. Implementation of BMPs reduces erosion and the rerouting of water associated with roads.

Roads are categorized as “National Forest System Roads” (NFSR) (dedicated under the area transportation plan) or “Undetermined” (non-dedicated roads, which are not considered to be a current part of the road system). The road miles which fall into the category of being dedicated roads (FS, State, and Private) are not calculated as contributing to soil disturbance as these are “permanent structures” and therefore have no relation to the 15% detrimental soil disturbance. This is due to the road system not being considered part of the suitable timber land base. However, the proposed temporary roads, excavated skid trails, and landings, and any existing undetermined roads do contribute toward the 15% standard. Implementation of BMPs reduces erosion associated with such roads.

There are approximately 35.6 total miles of road in the project area. Of the total, 35.6 miles are on Forest Service lands, 0 miles are privately owned and 0 miles are County roads. Of the 35.6 miles of roads on Forest Service lands, 35.4 are NFSR and 0.2 miles are Undetermined Road miles. Of the 35.4 miles of NFSR, 19.7 miles are restricted yearlong, 9.2 miles are open yearlong, and 6.5 miles are seasonally restricted. Refer to the Project File and the Hydrology Report for more detailed information about specific road conditions.

Timber Harvest

Harvest activities in the 1980s on FS lands included hand-fall and dozer skidding in lower relief land areas. Around the early to mid-1990s harvest activities was altered to skyline and rubber tire skidders and handfall/clipper cutting in land areas further up the drainage systems. Two of the more important impacts to soils are detrimental soil disturbance (compaction, displacement, rutting, etc.) and removal of organic matter. Soil disturbance as a result of timber harvest and fuels reduction is usually associated with mechanized activity (Kuennen 2006b).

Soil compaction impacts recover over time due to freeze/thaw activity, burrowing by animals, plant root growth, wetting/drying, and the action of soil microbes. Soil erosion and displacement are impacts that require a longer
Soils

timeframe to recover since the rate of soil formation is very slow. Long-term soil processes are influenced by
fire, mass wasting, wind-deposition, and weathering of parent material at the rate of one inch of topsoil formed
every 300-1000 years (Thurow 1991). To date a total of 810 regeneration harvest and 1123 intermediate harvest
are recorded between 1960s and present date for a sum of approximately 1933 acres within the project area on
FS lands.

Fire

The entire project area is estimated to have burned in the fire of 1889 and 1910. In 1910 approximately 8,092
acres or 88% of the area burned as a result of lightning strikes and high winds. Between 1940 and 2013 there
were 18 lightning strike fires and 1 human caused fire typically ranging in size between 0.25-5 acres. These
smaller spot fires are believed to have only impacted very small areas of land upon occurrence. Prior to 1940
fires were not recorded as they are being tracked currently.

Many fire effects on soil are not observable with the naked eye (Parsons et al. 2010). Severe deteriorating
effects that wildfires have on soils include loss of organics and nutrients and a reduction of water infiltration
(Wells et al. 1979). Burns that create very high soil surface temperatures, particularly when soil moisture
content is low, may result in an almost complete loss of soil microbial populations, woody debris, and the
protective duff and litter layer over mineral soil. Since erosion increases following fire activity are often directly
proportional to fire intensity (Megahan 1990), the removal of ash-capped surface soils as related to soil
disturbance could reduce soil productivity. As a result, many of the nutrients present in surface organics and
large woody debris can also be lost to the atmosphere through volatilization and removed from the site in ash-fly
(DeBano 1991; Amaranthus 1989).

Depending on fire severity and activity characteristics, many plants will survive and re-initiate growth soon after
a fire. However, the ability of surviving plants to reestablish, thrive, and reseed in subsequent years is greatly
affected by the presence of invasive plants and weeds (Goodwin and Sheley 2001). Burned areas can contain
high initial nutrient levels, exposed ground surfaces, and low shade with high light conditions which all directly
favor colonization of invasive plant species. Invasive plant survival coupled with fire disturbance can cause
rapid expansion of invasive plant growth. As a result, values such as wildlife habitat, watershed stability, and
water quality often deteriorate.

A wildfire occurring on sites with accumulated fuels could result in areas of high burn severity and
hydrophobicity (water repellant soils). This impact is greatly amplified by increased burn severity (Huffman et
al. 2001). The heat of a fire vaporizes hydrophobic compounds in the organic matter and moves them into the
soil layer where they condense and form a water repellant coating on the soil particles. Soil hydrophobicity
usually returns to pre-burn conditions in no more than 6 years (DeBano 1981; Dyrness 1976) and other studies
have documented a much more rapid recovery of 1 to 3 years (Huffman et al. 2001). However, before water
infiltration rates improve, increased overland runoff and sediment movement may occur. The primary risks for
erosion and mass failure during this timeframe is related to roads, especially where stream crossings are located.
Although natural fires such as lightning originated typically are lacking discernable effects on soils some
discernable effects have been noted in areas where fuel abatement activities burned too hot.

Disturbance of soils from fire suppression is usually limited to hand tools. Such activities have only minor
(insignificant) impacts to the soil resource. During fire suppression, closed roads may be reopened for access
and incorporated as fire lines. As part of the post-fire work, the areas of disturbance are rehabilitated and the
roads returned to the previous conditions in most cases. Using FW-GDL-SOIL-05 all potential fire concerns
will be met regarding soils.
ENVIRONMENTAL CONSEQUENCES

DIRECT AND INDIRECT EFFECTS

MEASUREMENT INDICATORS

The Helwick project area contains 2 Alternatives – the No Action (Alternative 1) and the proposed action (Alternative 2) henceforth referred to as Alternatives 1 and 2. Since no significant issues were identified for Soil Resources during the scoping process therefor, law regulation, and policy drive the effects analysis. Specifically:

- Compliance with NFMA; and
- Compliance with 2015 Forest Plan Standard.

Effects of the Alternatives on soil resources will be analyzed in terms of:

1. Activities on Sensitive Soils;
2. Detrimental Soil Disturbance and the 15% Standard;
3. Prescribed Fuels Treatments; and

SENSITIVE SOILS

Table S-5 displays the acres of management activities on sensitive soils by alternative.

<table>
<thead>
<tr>
<th>Sensitive Soils</th>
<th>Alt 1</th>
<th>Alt 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Acres of Proposed Harvest</td>
<td>0</td>
<td>655</td>
</tr>
<tr>
<td>Harvest Acres on Landtypes of Concern</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>% of Proposed Harvest Acres on Landtypes of Concern</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Proposed Harvest Acres on Low Productivity Soils (105, 201, 360, 403, 405, and 503)</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>% of Harvest Activities on Low Productivity Landtypes (105, 201, 360, 403, 405, and 503)</td>
<td>0%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Proposed Non-Harvest Burn Prescription Units</td>
<td>0</td>
<td>710</td>
</tr>
<tr>
<td>Total Acres Proposed Fuel Treatments on Landtypes of Concern</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>% of Proposed Fuel Treatment Acres on Landtypes of Concern</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Total Acres Proposed Fuel Treatment Prescription Units on Low Productivity Soils (Landtype 503)</td>
<td>0</td>
<td>82</td>
</tr>
<tr>
<td>% of Proposed Fuel Treatment Prescription Units on Low Productivity Soils (Landtype 503)</td>
<td>0</td>
<td>12%</td>
</tr>
</tbody>
</table>
Effects of the No Action Alternative 1 - Sensitive Soils

**Alternative 1** does not propose any new management activities on sensitive soils. Therefore, no direct, indirect, or cumulative effects to sensitive soils would result from Alternative 1.

Direct and Indirect Effects of the Proposed Action – Sensitive Soils

Landtypes 102, 112, 325, 351, 365, 370, and 520 are all considered as being a landtypes of concern (Kuennen 2006c). Under Alternative 2 no harvest activities are proposed to occur on these landtypes. As a result no direct or indirect impacts related to this factor are anticipated to occur.

Landtypes 105, 201, 360, 403, 405, and 503 are all considered as being low productivity soils. Of the proposed units harvest Unit 17 and Fuel Units 204, and 208, all contain the low productivity landtype 503. Recall that low productivity soils are directly related to timber suitability. Under Alternative 2 a total of 4 acres located in harvest Unit 17 will occur on low productivity soils. This value equates to <1% of the total harvest to be on low productivity soil (Soils Table S-5). Similarly the low productivity landtype 503 is located in both Fuel Units 204 and 208 which involve only fuel treatments and do not involve harvest equipment activities. Such activities involve a total of 86 acres located on low productivity landtype 503 within the Helwick Planning Area for a total of 12% of the total Fuel Acres being affected under Alternative 2 (Table S-5). The proposed activities are expected to open these stands of dead or dying trees due to root disease to become regenerated with a healthy second growth stock. This would allow for a continuous input of nutrients through needle-cast and coarse woody debris and would maintain soil productivity. Potential indirect effects of proposed burn only units on low productivity soils may include a slower vegetative return associated with reductions in nutrient cycling capabilities (discussed in more detail later in document).

In accordance with FW-GDL-SOIL-03; on nutrient-limited landtypes, harvesting organics should remain on site for at least 6 months or over a winter season to allow foliage nutrients to leach into the soil, except where site-specific analysis indicates the fuels would present unacceptable hazard. It should be noted that only 4 acres (<1%) of the total harvest acres are proposed on nutrient limited landtypes. Following harvest in Unit 17, fuel abatement will not occur until 6 months or greater past harvest activities so nutrients will re-enter the soil system. Therefore FW-DC-SOIL-03 and FW-GDL-SOIL-03 will be met.

Detrimental Soils Disturbance (DSD)

Management activities including, but not limited to, road construction, off-highway vehicle use, timber harvest (trails and landings), mechanical fuel treatments, firewood gathering, and grazing are considered to be potential sources of detrimental soil disturbance. Refer to the Soil Project File for spatial representation of past harvests.

Soils Table 3-6 displays existing, proposed, and cumulative DSD for each activity area. Existing disturbance is based on field surveys. Predicting detrimental and foreseeable activity disturbance is based on information from Kuennen 2003; 2006d; 2006e; USDA Forest Service 2011b; and Gier et al. 2013 (publication in process), which includes a summary of all Kootenai Forest Soils Monitoring to date with recommendations for analysis based on field results. The cumulative percent is derived by adding the percentage of disturbance expected from proposed activities and reasonably foreseeable activities to the existing disturbance percentage. All harvest activities, prescribed burning, skid trails, landings, fire lines, excavator piling, and temporary roads are included in this analysis. Best Management Practices (BMPs) would be followed (Appendix B), and additional design criteria have been specified in order to minimize disturbance (refer to the Design Criteria in Chapter 2). Complete soils survey data can be found in the Soil project file at the Cabinet Ranger District.
Table S-6. Existing, During and Cumulative DSD in Each Proposed Harvest Unit

<table>
<thead>
<tr>
<th>Unit #</th>
<th>Activity Area (acres) Alt 2</th>
<th>Existing Detrimental Soil Disturbance DSD (%)(^1)</th>
<th>Alternatives 1/2</th>
<th>Potential DSD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Existing DETRIMENTAL SOIL DISTURBANCE DSD (%)(^1)</td>
<td>Predicted Temp Road DSD%</td>
<td>Predicted Harvest DSD%(^2)</td>
</tr>
<tr>
<td>1</td>
<td>65</td>
<td>0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>3</td>
<td>0/0</td>
<td>0/1,3</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>4</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>12</td>
<td>0/0</td>
<td>0/4,3</td>
</tr>
<tr>
<td>10A</td>
<td>23</td>
<td>12</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>9</td>
<td>0/0</td>
<td>0/4,3</td>
</tr>
<tr>
<td>12</td>
<td>55</td>
<td>0</td>
<td>0/0</td>
<td>0/1,3</td>
</tr>
<tr>
<td>13</td>
<td>22</td>
<td>&lt;1</td>
<td>0/0</td>
<td>0/1,3</td>
</tr>
<tr>
<td>14</td>
<td>9</td>
<td>2</td>
<td>0/0</td>
<td>0/8</td>
</tr>
<tr>
<td>15</td>
<td>64</td>
<td>7</td>
<td>0/0</td>
<td>0/8</td>
</tr>
<tr>
<td>16</td>
<td>11</td>
<td>&lt;1</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>17</td>
<td>33</td>
<td>&lt;1</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>18</td>
<td>23</td>
<td>&lt;1</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>19</td>
<td>6</td>
<td>&lt;1</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>20</td>
<td>23</td>
<td>&lt;1</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>21</td>
<td>24</td>
<td>2</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>22</td>
<td>121</td>
<td>&lt;1</td>
<td>0/0</td>
<td>0/1</td>
</tr>
</tbody>
</table>

TOTAL HARVEST ACRES: ALT 2 = 655

FUELS UNITS

<table>
<thead>
<tr>
<th>Unit #</th>
<th>Activity Area (acres) Alt 2</th>
<th>Existing Detrimental Soil Disturbance DSD (%)(^1)</th>
<th>Alternatives 1/2</th>
<th>Potential DSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>30</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>201</td>
<td>11</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>202</td>
<td>24</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>203</td>
<td>74</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>204</td>
<td>124</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>205</td>
<td>13</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>206</td>
<td>124</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>207</td>
<td>27</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>208</td>
<td>17</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>209</td>
<td>76</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>210</td>
<td>89</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>211</td>
<td>82</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>212</td>
<td>19</td>
<td>Not Sampled</td>
<td>0/0</td>
<td>0/0</td>
</tr>
</tbody>
</table>

TOTAL FUELS ACRES BY ALTERNATIVE: ALT 2 = 710
The Helwick soil survey was conducted using the new Region 1 Soil Sampling Protocol which meets the R1 definition of detrimental soil disturbance, and therefore the Helwick pre-activity conditions meet the R1 definitions. Field forms are present in the Helwick Soil files.

Predicted DSD has been calculated based on historical soil monitoring data collected in the field in post-harvest timber sale units. (Kuennen, 2006a). In units with combined tractor/skyline harvest activity the anticipated DSD was calculated as related to the overall acreage of potential disturbance by harvest activity.

Skyline/cable units which have a potential for having the trees dropped mechanically but brought to landings using a cable system.

For determining temporary road soil disturbance an average width of 12’ has been applied to calculate the area of DSD. Following harvest all temp roads and landings used for harvest activities will be scarified to at least 6-12” based on the depth.

In proposed ground based secondary entry harvest units currently exceeding 8% DSD the analysis of this project assumes that 50 percent disturbance value compared to similar harvest activities on currently undisturbed soils (Louis Kuennen pers. Comm. 2011). This value presumes that secondary entry harvest activities will be re-using approximately 50% of the already existing historic skid trails in ground based units will be reused during proposed harvest operations. It is assumed that units containing less than 8% DSD are more historic in nature and are on a recovery trend as displayed by revegetation of historic skid trails and second-growth stand conditions. As a result the reduction in secondary entry values will not apply to these stands. This is present in Units 10 and 11 which are ground based harvest units while Unit 10A exceeds 8% DSD (pre-harvest DSD) but is a skyline harvest unit.

Reduction in percent DSD is expected to occur in 3 years following harvest activity. Such impacts only apply to those areas where heavy equipment is suspected to be used. Based on higher post-harvest cumulative effects to soils recommend grapple piling from skid trails in Units 10 and 11 in order to avoid exceeding the 15% DSD value.

Note: An existing condition of <1% can mean either: 1) No disturbance is present or 2) there is some disturbance present but does not equate to 1%.

Effects of the No Action Alternative 1 – DSD

Under Alternative 1 timber harvest and other activities proposed with this project would not occur. However, natural changes in climate and vegetation would continue to occur. Should Alternative 1 be selected the existing DSD values will be trending towards desired conditions. Vegetation regeneration and stand growth activities would continue to slowly recover over time on existing harvest units resulting in lower compaction values due to tree root growth, freeze-thaw activities, and increased soil nutrients from the decomposition of forest litter and CWD. Therefore, no direct, indirect, or cumulative DSD would result from Alternative 1.

Direct and Indirect Effects of Alternative 2 – DSD

The percent detrimental soil disturbance (DSD) is the measurement indicator of soil compaction for this analysis. Direct impacts on soils from management activities could include compaction, rutting, and displacement. Typically these impacts take place as a result of vehicles/equipment traversing areas within proposed units such as skid trails, landings, and temporary roads. Soil compaction is most common where heavy equipment makes repeated passes over the same ground, particularly during times of high soil moisture (Kuennen 2003). Soil compaction can change slope hydrology and lead to overland flow of water during
precipitation or snowmelt events. Compacted soils can also reduce soil productivity. These are some general direct effects that can occur with all timber harvest activities. Table S-6 identifies the extent of potential impacts which may occur under Alternative 2.

The construction of a fire line directly impacts soils by removing (displacing) the organic layer down to mineral soil for 2-3 feet wide around the perimeter of the units. Some compaction along the fire line could occur if created using heavy equipment. The effects of potential fire line construction are included in Table S-6 and apply only to those units where machinery may be involved in such activities. Similarly, some of the units will have post-harvest slash treatments which are also anticipated to potentially impact soils DSD. These are located in Units 10, 11, 14 where machinery grapple pile activities are scheduled to occur following harvest activities. Because mechanical piling can reduce the amount of woody material within a unit, it can also affect nutrient cycling.

Fuels treatments will not include mechanical piling or harvest related aspects. As a result no impacts to Soils DSD are anticipated to occur in all of the Fuels Units. Nutrient cycling related to woody debris is discussed in depth below.

Regeneration harvest activities would not result in multiple entries to reach the desired silvicultural objectives over time. Related post-harvest unit entry over time would be for thinning and scheduled to occur several decades later. Regeneration harvest activities such as shelterwood and seedtree harvest prescriptions would require one entry to reach the target vegetative goal. Proposed regeneration harvest units include the following units: 1, 2, 3, 4, 5, 6, 7, 9, 10A, 11, 13, 14, 17, 18, 19, 20, and 21. This being said, units proposed with intermediate harvest prescription such as commercial thinning or stand improvement operations are more subjective to higher detrimental soil disturbance than that of a regeneration prescription. Intermediate harvest operations are prescribed in the following units: 8, 10, 12, 15, 16, and 22.

Indirect impacts from management activities could include erosion from surface water runoff being channeled into ruts, fire lines, and/or along temporary roads within units. With less vegetation a conversion from a drier soil environment to a slightly moister site would occur. Less vegetation would mean a thinner canopy and more soil interception from rainfall above. These impacts would be minimized by implementing BMPs and following specific management requirements and design criteria to the extent possible.

In units where existing historical skid trails already exist, these skid trails would be used to the extent feasible to minimize additional DSD. However, new skid trails may be required in areas where the existing skid trail network does not fit the current operations. Effects of temporary roads and skid trails would be temporary due to planned ripping and seeding following harvest activities in areas used for harvest operations to remedy compaction. Such activities would help offset disturbance related to harvest activities to soil productivity by allowing previously disturbed soils to re-establish as a productive area capable of producing future natural vegetative cover which in turn may one day be harvested again. In accordance with FW-DC-SOIL-04, while some increase in DSD is expected with proposed management activities, all activity areas are expected to remain at/or below the 15% soil quality standards and in the long run soil conditions will be trending towards desired conditions by enhancing secondary stand replacement in areas of diminishing stands. Skyline harvest activities would be required in areas of steep slopes in order to reduce soil disturbance as a result of soil displacement by tracked equipment such as clipper cutters or rubber tire skidders. All skyline harvest units without a road at the bottom would also require hand fall activities. Any alterations in the proposed harvest techniques will be determined in coordination with the forest soil scientist on a case-by-case basis.

**Cumulative Effects**

Soil impacts associated with harvest operations may be best mitigated by operating equipment during drier soil conditions or winter months on frozen grounds. Other landform sensitivities have been considered when
designing proposed harvest procedures and determining which types of equipment should be allowed based on slopes and soil conditions.

The only Unit found to cumulatively exceed the 15% DSD value in proposed Action Alternative 2 is Unit 10. As mentioned above, Unit 10 is an intermediate harvest prescription where past activities have already occurred. As a result, the existing condition was found to have a relatively high soil disturbance value (Refer to Table S-6 above). New skid trails may be required in areas where the existing skid trail network does not fit the current operations. Effects of temporary roads and skid trails on vegetative regrowth are expected to be temporary due to planned ripping and seeding following harvest operations.

Post-harvest rehabilitation activities in order to meet the Forest Plan and R1-Supplement 2500-99-1 would include ripping skid trails and temporary roads and seeding as necessary. These activities would help to offset the harvest activities to soil productivity by allowing previously disturbed soils to re-establish as a productive area capable of producing future natural vegetative cover which in turn may one day be harvested again. In order to address the possible exceedance of 15% DSD values for Unit 10, following harvest and fuel abatement procedures this unit would be re-sampled by the Forest Soil Scientist. If the measured DSD values exceed 15% it will be required to complete soil re-habilitation procedures. Such activities involve subsoiling or ripping the soils in skid trails and landings used by the purchaser during harvest activities. The subsoiler is an excavator designed specifically to resolve the severe soil compaction that developed as a result of repeated heavy equipment use in timber sales. The subsoiling excavator bucket typically contains two shanks and benefits or reduces soil compaction by digging into the soils, lifting up and releasing the soil. Such activities do not rotate the soil horizonation but simply reduces soil compaction. The area required to be subsoiled later in time will be related to the post-harvest DSD values. These activities have proven useful in a variety of projects including pre-commercial thinning, forest health, fuel reduction, forage enhancement, and brush removal (Archuleta et al. 2008; Joplin 2009). Harvest operations may also include placing downed woody material on skid trails to reduce impacts to soils. In proposed ground based harvest units currently exceeding 8% DSD this analysis assumes that 50 percent of historic skid trails will be reused during harvest operations. It should be noted that none of the units are located on landslide prone areas; therefore, FW-GDL-SOIL-04 does not apply.

The soil rehabilitation effects may not be immediately apparent, as it will take several years for diverse native vegetation to establish in areas that previously had limited root capacity. Disturbed soil organic layers, which play an important role in soil nutrient cycling and microbial population/function, would also take time to rebuild after rehabilitation treatments. The importance of the rehabilitation cannot be overlooked because it does not immediately restore soils to pre-disturbance conditions. The rehabilitation provides the critical bridge that allows these natural processes to improve or trend towards desired conditions over time. Based on this analysis, while some increase in DSD is expected with proposed management activities, Alternative 2 will be trending towards desired future conditions following soil mitigation and rehabilitation activities. Plans are to monitor some of the units within the Helwick project area that have currently existing higher DSD values within 2-3 years following harvest operations to determine the recovery ratio of the soils to compare pre-existing to post-existing conditions.

**Permanent Roads**

It should be noted that authorized Forest Roads as defined in 36 CFR 212.1 are not considered part of the productive land base. As a result, these features do not count toward the 15% soil quality standard (FSM 2500-2009-1). Under Alternative 1 no new road construction will occur. Under Alternative 2 approximately 3.6 miles of new authorized Forest Service Roads is scheduled for construction to reach units 1, 3, 10, 10A, and 12. When broken down individually approximately 0.8 miles of permanent FS Road 2262A will be constructed to reach units 1 and 3 while approximately 1.2 miles of FS 301A will be constructed to reach units 10 and 10A. At the same time 0.5 miles of FS Road 301B and 1.1 miles of road 14762 will be constructed to reach Unit 12.
Additionally, Alternative 2 will require approximately 18 miles of road reconstruction. All new road reconstruction would be required to meet Montana State BMPs and FW-GDL-SOIL-05.

**Temporary Roads, Landings, and Skid Trails**

All new temporary roads and skid trails are considered 100% detrimentally disturbed through removal of organic matter and compaction. To meet Regional Standards, the skid trails within Units 15, 18, and 21 would be ripped and/or re-contoured and covered with slash and CWD; FW-GDL-SOIL-02 and FW-GDL-VEG-03. Indirect effects from the action alternative include the temporary erosion related to exposure of mineral soil associated with skid activities. Without a protective mat of vegetation and stable soil profile these areas are more susceptible to erosive forces of wind, water and dynamic temperature changes (frost heaves) sometimes seen in and around the Helwick analysis area. These localized effects are typically short-term (5-10 years) due to the warmer wet climate found in the SW portion of the KNF. It should be noted that frost-heave activities are believed to be one of the most important activities associated with long term soil amelioration on the KNF (Kuennen pers. comm. 2015).

All landings for the sale would be agreed upon by the FS and purchaser. These areas would be constructed and used in adherence with BMPs and RHCAs to minimize their impacts to soils. After use, all landing surfaces would be ripped or scarified (6-12") to remedy soil compaction, seeding, and woody debris would be spread to stabilize soil from movement and to provide organic material on the road prism and water bars installed as appropriate to reduce water routing. These activities will help offset the harvest impacts to soil productivity by allowing previously disturbed soils to re-establish as a productive area capable of producing future natural vegetative cover which in turn may one day be harvested again. Based on this analysis, while some increase in DSD is expected with propose management activities, all activity areas are expected to remain at/or below the 15% soil quality standard and trending towards desired conditions.

**FUELS TREATMENTS**

Due to the suppression of wildfires over the last century, fuels have accumulated in many areas throughout the analysis area. The intent of fuels treatments is to reduce fuel levels and meet vegetation management objectives. Table S-7 displays the fuels treatment proposed for Alternative 2 as compared to the No Action Alternative.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Alt 1</th>
<th>Alt 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed harvest by Alternative</td>
<td>0</td>
<td>655</td>
</tr>
<tr>
<td>Proposed Harvest with Grapple Pile</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>Proposed Harvest with Underburn</td>
<td>0</td>
<td>469</td>
</tr>
<tr>
<td>Natural Fuel Treatments – Burn Only</td>
<td>0</td>
<td>539</td>
</tr>
<tr>
<td>Natural Fuel Treatments – Mechanical Hand Slash and Burn</td>
<td>0</td>
<td>171</td>
</tr>
<tr>
<td>Total Fuels Treatments No harvest</td>
<td>0</td>
<td>710</td>
</tr>
</tbody>
</table>

**Effects of the No Action Alternative 1 – Fuels Treatments**

Alternative 1 does not propose any fuels treatments. Therefore, no direct, indirect, or cumulative effects to soils would occur from Alternative 1. Alternative 1 would also not reduce fuel loading in the analysis area. As a result, there would be a greater risk of indirect effects caused by high intensity wildfire and greater potential for
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damaging soil heating (Keane et al. 2002). The potential effects include alteration of soil structure, impacts to soil invertebrates, reduced nitrogen, and loss of soluble nutrients (Kuennen 2000). However, past experience with wildfires on Kootenai National Forest indicate that there is a very low risk of these effects even with high intensity fire.

**Direct and Indirect Effects of Alternative 2 – Fuels Treatments**

Approximately 710 acres (Alternative 2) of natural and activity fuels burning is expected to be implemented in the next 5 years (2015-2020) in the Planning Area. Light, short-duration burning that does not consume the entire duff layer does not strongly affect soils. Duff acts as an insulator, protecting the soil from excessive heating (Hartford and Frandsen 1992). Effects of this type of burning are generally short-lived (Neary et al. 1999). Alternative 2 contains underburn activities for all harvest units except Units 10, 11, 17, and 22 for a total of 469 acres. Under Alternative 2 Units 10, 11, and 14 would be grapple piled (32 acres) while Units 17 and 22 propose to take the non-saw material (154 acres) as a slash treatment. It should be noted that this mechanical activity has already been included previously in the DSD calculation (refer to Table S-6.

Proposed fuel units include only burn and slash and burn activities. In the proposed action a total of 539 acres of the natural fuel units involves burn activities 171 acres as will be slash and burn activities. All fuel treatments both inside and outside of WUI do not involve any mechanical activities. Acreage sums may vary slightly with time based on what is found in the field as being physically capable of completing without resulting in negative impacts that may outweigh the overall benefits to the local soil ecology.

The burning prescriptions in Alternative 2 were designed to provide only the fire intensity needed to achieve the vegetative management objectives. Direct effects resulting from burn activities such as under-burning can result in soil heating and associated soil impacts such as loss of organic matter, impacts to soil organisms, and creation of water repellency. The potential for these impacts are minimized because the burning prescriptions for this project were designed for low to moderate fire intensity and would be implemented when soil moisture levels are high. Typically, burning is scheduled when the moisture in the lower duff layers is high enough so that the fire does not consume those layers, which insulate the soil from surface heating (DeBano 2000). When soils have adequate moisture to retain their biological, chemical, and physical integrity, effects from the loss of forest floor can be minimized (Barnett 1989; Frandsen and Ryan 1985; Hungerford et al. 1991; McNabb and Cromack 1990). Prescribed pile burning could potentially remove woody debris that would otherwise provide nutrient to the soil as the decay process occurs (Page-Dumroese et al. 2006). Hence, burning when soil moisture content is high helps to maintain coarse woody debris requirements. This is typically completed in early spring or late fall on the KNF.

Although a small portion of the nutrients would be lost through leaching, most of the nutrients would remain attached to or between the soil particles on-site. The re-introduction of fire in the analysis area is consistent with the ecological understanding of these forest types (Arno 1996). Positive impacts may result in a short-term (1 to 2 years) increase in plant-available nutrients (Choromanska and Deluca 2001; Hart et al 2005; Certini 2005). Additionally, MacKenzie et al. (2006) found that light to moderate fire effects may maintain higher nutrient availability in the long-term with the positive influences from charcoal. Therefore, implementation of an action alternative containing post-harvest burns is expected in the long term to trend the conditions towards a desired condition regarding nutrient cycling in the Analysis Area. This is supported by Forest Soil Productivity Monitoring (refer to the Soil Project File).
NUTRIENT CYCLING

Forest ecosystems have evolved with a continual flux of coarse woody debris (CWD). As defined in the 2015 Forest Plan: Coarse woody debris consists of dead woody material larger than 3 inches in diameter and derived from tree limbs, boles, in various stages of decay (Graham et al. 1994; Brown et al. 2003). In the 2015 Forest Plan, the CWD recommendations for the individual habitat types were aggregated into five general categories – two were Warm/Dry Biophysical Setting, one for Warm/Moist Biophysical Setting, and two for Subalpine Biophysical Setting. Those five correspond to Vegetative Response Units (VRUs) and can also be correlated with Habitat Type Groups. CWD performs many physical, chemical, and biological functions in the forest ecosystems. Physically it protects the forest floor and mineral soil from erosion and mechanical disturbances. CWD disrupts airflow and provides shade, which insulates and protects new forest growth and also has significant water holding capacity, making it an important source of moisture for vegetation during dry periods. This decaying woody debris provides nutrients, especially sulfur, phosphorus, and nitrogen, necessary for new plant growth. CWD also hosts ectomycorrhize, micro-organisms that play an important role in the uptake of nutrients and water by woody plants (Graham et al 1994).

Retaining coarse woody debris and organic matter is important to maintaining the soils most productive layer (FW-DC-SOIL-01; FW-DC-SOIL-04; FW-GDL-SOIL-02; FW-GDL-VEG-03). The importance of soil organic matter (duff layer) is indispensable to productivity and the ecological function of soils (Brady and Weil 2002). This organic component contains a large reserve of nutrients and carbon, and typically includes the majority of microbial activity within the soil column. Forest soil organic matter influences many critical ecosystem processes such as the formation of soil structure, which in turn influences soil water infiltration rates and soil water holding capacity. Soil organic matter is also the primary location of nutrient recycling and humus formation, which enhances overall soil fertility.

Effects of the No Action Alternative 1 – Nutrient Cycling

Alternative 1 does not propose any new management activities. Therefore, no direct, indirect, or cumulative effects to nutrient cycling could result from Alternative 1. Nutrient cycling would continue at present rates until a natural disturbance occurs.

Direct and Indirect Effects of Alternative 2 – Nutrient Cycling

A direct impact from management activities in Alternative 2 would be the removal of woody material from proposed timber harvest units. The removal of all or most of the organic material (both duff layers and CWD) from a site can cause temporary nutrient deficits that may affect physical and biological soil conditions (Brady and Weil 2002; Graham et al. 1994; Brown et al. 2003). To avoid this, it is important to maintain both fine and CWD on managed sites, especially regeneration harvest units where most of the organic matter is removed (Graham et al. 1994; Brown et al. 2003). Allowing the accumulation and decomposition of a range of sizes of woody debris maintains both short-term and long-term soil productivity. The different decomposition rates provide for the slow, continual release of nutrients.

This project was designed to provide for a continuous supply of woody material based on recommendations from Graham et al. (1994) and Brown et al. (2003). In harvest stands where more of the overstory is being removed, each activity area has been assigned a habitat-specific retention level for CWD (Table S-8). In both regeneration and intermediate harvest units with underburn, or grapple pile activities, post-harvest stands would remain fully stocked, which would provide for yearly nutrient inputs through litter fall (Brady and Weil 2002) and long-term CWD as a result of future blow-down and disease. Therefore, these units would meet the CWD requirements left on the ground following harvest activity and FW-GDL-SOIL-02 and FW-GDL-VEG-03 will
be met as required under the 2015 Forest Plan. Such values suggest that regardless of the Alternative selected the project will be trending towards the desired conditions.

Table S-8. Recommended Levels of CWD (> 3’ diameter) for proposed timber treatment units

<table>
<thead>
<tr>
<th>Tons Acre^</th>
<th>Biophysical Setting</th>
<th>Unit(s)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>Warm Dry</td>
<td>10, 10A, 11, 13, 14, 15, 16, 17, 18, 19, 20, and 21</td>
</tr>
<tr>
<td>15-30</td>
<td>Warm Moist / Cool Moist</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, and 22</td>
</tr>
</tbody>
</table>

*Some units may be listed under more than one Forest Type based on multiple habitat types being present in the unit and/or varying harvest prescriptions based on the proposed alternative.

^It should be noted that the Biophysical Setting CWD values should be looked at as a local estimation and are dependent on local precipitation levels and vary across the KNF from north to south.

In summary, soil productivity would be maintained through retention of CWD at levels recommended in the 2015 Forest Plan for the proposed action. Therefore, implementation of the action alternative is not expected to adversely impact nutrient cycling in the Analysis Area and FW-GDL-SOIL-02 and FW-GDL-VEG-03 will be met.

CUMULATIVE EFFECTS

Cumulative effects are the result of all the impacts that past, current, and reasonably foreseeable activities have on a resource. A summary of activities are listed in Chapter 3. The results of past activities have resulted in the “Existing Condition” described above. The anticipated effects from proposed activities were then added to the existing condition and described in the section titled “Direct and Indirect Effects.” The sum of the existing condition (including past actions) and the direct and indirect effects of proposed actions combined with current and reasonably foreseeable actions result in the cumulative effects described in this section.

The spatial scale or geographic bounds for consideration of cumulative effects consists of the same activity areas analyzed used in existing condition, direct, and indirect effects. This is appropriate because soil productivity is spatially static and productivity in one location does not affect productivity in another location. The activity areas are delineated as directed by Forest Service Manual R-1 Supplement No. 2500-99-1.

The temporal scale is dependent on the issue being addressed with no one scale being appropriate for all issues. The analysis may need to evaluate the effects of proposed management over all seasons for several days, years, and even decades. This is complicated by data constraints that require constant monitoring to detect change – though data is often insufficient to identify even trends or trajectories of change until the impact is large enough or has been occurring for some time. Furthermore, there is often a lag between some actions and the observed effect. This is particularly true for Soils. This analysis strives toward an integrated approach to soil processes and function to project future trends in response to proposed management options to the best abilities.

CURRENT VERSUS HISTORIC MANAGEMENT PRACTICES

There are marked differences between past and current land management practices and policies. The evolution that has taken place with regard to land management practices is the result of science, technology, ongoing monitoring actions, and changing public values.
Prior to around 1990, the harvest methods focused primarily on providing low-cost wood products. Logging systems were selected primarily by the least expensive method to transport trees from the forest to the mill. Tractor skidding was typically used and trails and landings were not minimized. Harvest on steeper slopes, at times, involved stair-step excavated trails (i.e. jammer roads, which became less common in the 1970s). In addition to harvest activities, fuels reduction and site preparation for natural regeneration or planting many times consisted of dozer piling. Many of these practices led to excess soil disturbance and increased the risk of erosion.

Over the last 20 years, impacts to soil and water resources from logging activities have been reduced because of Best Management Practices (BMPs), the Inland Native Fish Strategy (INFS), and changes in science, technology, etc. Based on research studies, current BMPs and INFS riparian habitat conservation areas (RHCAs) can reduce sediment delivery to streams compared with historical practices (Lee et al. 1997; USDA Forest Service 1995b). Harvest methods and removal of timber products from the national forest changed substantially over time. Modern timber harvest prescriptions and design emphasize desired conditions of the forest after timber harvest. This often results in the retention of various amounts of trees in a post-harvest stand to address objectives that may include seed production, shelter for the site, watershed objectives, soil productivity, wildlife, and others. Elements of modern harvest prescriptions that address specific resource concerns include retention of snags and down wood for soil nutrition, minimizing the number of skid trails, and maintaining sediment filtering vegetation in riparian areas near lakes and streams. Jammer roads and dozer piling rarely occurs. The following BMPs apply to the Helwick project area:

- Avoid equipment activities on sensitive soils such as landslides or unstable slopes within unit boundaries.
- Use excavator for mechanized slash piling and fire line construction.
- Avoid skidding on unstable slopes and slopes that exceed 40% unless not causing excessive erosion (State of Montana BMPS Section IV.B).
- Rehabilitate and re-seed project areas. B6.6, C6.6, C6.601#, 6.632#, C6.633#
- Space skid trails 75 to 100 feet apart.
- Ensure that enough coarse woody debris is left to sustain long term soil productivity while still meeting fuel reduction objectives. C6.406#, C6.7
- Grapple pile unit 10, 11, and 14 from skid trails following harvest activities in order to reduce the potential of exceeding the 15% DSD value.
- Removal of slash to the landing using whole tree yarding
- Controlling erosion during and after harvest activities to protect water quality and soil productivity. Some examples include ripping and/or water barring skid trails and landings, seeding and fertilizing, spraying for weeds, etc. C6.6, C6.632#, C6.633#
- Due to slopes generally exceeding 45%, soil physical conditions, and the lack of an existing road at the bottom of the unit, no mechanical harvest activities would be allowed in skyline yarding units 1, 3, 4, 5, 6, 7, 8, 9, 10A, 16, 17, 18, 19, 20, 21, and 22.

Project specific best management practices (BMPs) shall be incorporated into all land management activities as a principle mechanism for protecting soil resources (FW-GDL-SOIL-05).
ONGOING AND REASONABLY FORESEEABLE ACTIONS

In the following discussion, the effects of past, current, and/or reasonably foreseeable activities are considered cumulatively with activities proposed with this project. The effects were either described as not contributing effects, contributing indiscernible effects, or having measurable effects on water resources.

Vegetation Management and Fuels Reduction Activities

There are no current or reasonably foreseeable Forest Service commercial timber sale projects planned within the analysis area. Therefore, no additional effects would be contributed from these activities.

Similarly, no pre-commercial thinning is currently identified but may occur in the ongoing and reasonably foreseeable future. It is expected that very minimal if any acres would be thinned within the analysis area over the next 10 years. Should such activities occur, it is expected that pre-commercial thinning would contribute indiscernible effects to soils within the analysis area. This is because pre-commercial thinning is done by hand and therefore no additional ground disturbance will occur. In addition, trees removed during thinning projects are left on-site.

It is expected that personal firewood collection will occur throughout the activity area. Neither of these activities create additional ground disturbance or remove enough vegetation to affect soil productivity and therefore would not contribute additional effects to soil resources.

In the 5 years following timber harvest approximately 75-80% of the stand is expected to be fully stocked. Depending on the Alternative selected between approximately 532-460 acres of harvest will require stocking. No heavy equipment is associated with tree planting. Tree planting does not create detrimental soil disturbance or increase sedimentation rates. Therefore, regardless of the Alternative selected, tree planting would not contribute additional effects to soil resources.

It is expected that there would be salvage of blown-down trees within the analysis area where trees left behind are more susceptible to higher wind speeds and potential timber damage. Treatment acres are not expected to exceed an estimated 20 acres per year over the next 10 years. Soil disturbance would be limited to existing trails, roads, and fire lines, and in some scattered places heat damage associated with fuel treatments that burned too hot. As a result very minimal detrimental soil disturbance is expected within the activity areas and existing soil conditions will continue to trend towards desired conditions. Some of the salvage is likely to occur outside of the units treated under the selected alternative; therefore, any such impacts would not be additive activity areas analyzed in this decision.

Road Maintenance

Routine road maintenance and/or road reconstruction work would occur as needed on roads in the Activity Area and would follow BMPs and forest plan riparian area management direction in order to minimize effects on soil resources and meet the approved management objectives (RMOs). Such activities include road blading, gate repair/replacement, cleaning and constructing ditches, cleaning culverts, installing culverts, replacing culverts with larger diameter culverts, installing drain dips and surface water deflectors, placing riprap to armor drainage structures, placement of aggregate, brushing, debris removal, and surface grading to restore drainage efficiency. Such activities are schedules to occur from FS boundaries to the top of the drainage basins to improve surface water management BMPs and trending hydrologic and soil conditions towards desired conditions.
Road Construction

Approximately 3.6 miles of new road will be needed to access the activity area while there is the potential to perform road reconstruction on approximately 18.51 miles of road in the project area. Proposed road reconstruction and maintenance may increase short-term sediment movement from road surface runoff initially but should be minimal, especially at road locations higher on the slope that are relatively low gradient and provide for sufficient buffer zones. Road maintenance includes culvert installation, blading, and brushing, and typically improves drainages and decreases erosion from water channeling down the road surface in the long run. Recall that road management of Authorized Forest Roads as defined in 36 CFR 212.1 are not considered a part of the productive land base. As a result, these features do not count toward the 15% soil quality standard (FSM 2500-2009-1). In addition these areas are already disturbed and no additional road construction is proposed. As a result, road management would have no cumulative effect on soils in the analysis areas because soil productivity effects are spatially static and productivity in one location does not affect productivity in another location.

Temporary Roads and Landings

Currently, no known timber harvest activity is planned within the Helwick project area in the near future that would involve temporary roads and landings aside from potential salvage and blowdown harvest. As stated below placement of temporary roads to access fire occurrence is likely to occur but the degree and timing is unknown. Following activities all landings used for harvest activities will be ripped to remedy compaction, the berm would be pulled back (on roads), woody debris would be spread to stabilize soil from movement and to provide organic material, and all disturbed areas would be seeded. Such activities would help to offset the harvest activities to soil productivity by allowing previously disturbed soils to re-establish as a productive area capable of producing future natural vegetative cover which in turn may one day be harvested again. As a result the cumulative effects related to temporary roads and landings seem more restricted to the proposed activity of the Helwick project area.

Fire Suppression

Fire suppression activities would occur as needed. Effects from wildfire suppression would vary with location and size of the fire; however suppression activities are expected to follow Forest Plan direction. Suppression of wildfires could have measurable effects to soils within the analysis area. These effects could include soil compaction, displacement, and erosion. Due to the unpredictable nature of wildfires, cumulative effects from future wildfire suppression activities could not be meaningfully quantified in this document.

Grazing

Historically livestock grazing on NFS lands by sheep and pack stock occurred on NFS lands following the 1910 fire in the project area. There are currently no active grazing allotments overlapping the activity areas that have occurred in the past 40+ years and no changes in livestock grazing is currently expected to occur in the near future. As a result, there are no cumulative effects related to grazing activities because soil productivity effects are spatially static and productivity in one location does not affect productivity in another location.

Invasive Plant Species Treatments

The control of invasive plant species on National Forest land is an ongoing activity that normally occurs within the summer months. The Kootenai National Forest Invasive Plant Management ROD (2007) provides direction for invasive plant species control on the District. Invasive plant species control is expected to continue over the
Soils

next 10 years. Most herbicide weed treatments are conducted along existing roads with very few treatments occurring in timber harvest units.

Effects of invasive plant species control are incorporated into this cumulative effects analysis through consideration of the effects disclosed in the Herbicide Weed Control EA, a review of the project database, and professional judgment and personal knowledge of noxious weed control. The findings of this assessment conclude that ongoing and reasonably foreseeable invasive plant species control within the analysis area would cumulatively contribute indiscernible effects to the soils resource. The level of invasive plant species control within the analysis area is not expected to increase much over the next 10 years. Most future applications would likely be focused along open or restricted roads on a 4 year treatment schedule providing funding allows for such activities to continue at this pace. All activities will follow approved application methods as analyzed in the Kootenai National Forest Invasive Plant Management ROD (2007); therefore no adverse cumulative effects would occur and conditions are expected to trend towards a more desired future condition regarding invasive plants.

Recreation Maintenance

Trail maintenance may include brushing; removing blowdown, debris, and hazard trees; repairing or adding waterbars; repairing treads; repairing or replacing signs; and improving vistas. Routine trail maintenance would have no effect on soils in the activity areas identified. Administrative sites and trails do not count toward the 15% standard. In addition, the trails are individually small, scattered across many watersheds, and not all work would occur in the same year.

Special Uses

Outfitter/guides are active during the big-game hunting season on the District, and may be active in the project area on any given day during the hunting season. Other activities include snowmobile use in the winter time and minerals exploration. Although there are several active mining claims within the project area none of these mines seem to be very active at this time and none are anticipated to occur in the future. Therefore, these activities would not add detrimental disturbance to the amounts listed in Table S-6. The level of special uses within the analysis area is not expected to change much over the next 10 years.

Public Uses

Recreational use of the project area is expected to include hiking, camping, fishing, hunting, photography, small forest product gathering (berries, mushrooms, cones, and boughs), Christmas tree cutting, firewood gathering, driving for pleasure, mountain biking, sightseeing, wildlife viewing, cross-country skiing, snowshoeing, trapping, and snowmobiling. These activities are expected to continue over the next 10 years. Because of increasing numbers of people moving into the local communities, it is expected that some of these activity levels would increase. Recreational activities would contribute indiscernible effects to soils. This conclusion is based on the fact that these activities are individually small and scattered across many watersheds.

According to USDA FS 2001 off-highway vehicle (OHV) use was left off the list above because it is currently limited only to existing trails and open roads (OHV Record of Decision and Plan Amendment for Montana, North Dakota, and Portions of South Dakota, 2001). Therefore, no additional disturbance is expected from OHV use because soil productivity effects are spatially static and productivity in one location does not affect productivity in another location. Regarding public use – overall soil conditions will continue to trend towards desired conditions.
Private Property

No private property is involved in this project area.

State Land Activities

Activities on state and provincial lands would have no effect on soils in the project area because soil productivity effects are spatially static and productivity in one location does not affect productivity in another location.

CONSISTENCY WITH REGULATORY FRAMEWORK

STATE AND FEDERAL LAWS AND REGULATIONS

The National Forest Management Act (NFMA) requires that all lands be managed to ensure maintenance of long-term soil productivity, hydrologic function, and ecosystem health. All activities proposed are consistent with this direction. Where a fully stocked timber stand remains on site future needle-cast and/or trending toward the CWD guidelines contained in Graham et al (1994) and Brown et al (2003) would assure long-term soil productivity (FW-GDL-SOIL-02). All activity areas would remain below 15 percent detrimentally disturbed soils, RHCAs would be delineated where appropriate, design criteria would be followed, and all applicable BMPs would be implemented (FW-GDL-SOIL-05).

FOREST PLAN DIRECTION

Under the 2015 Kootenai National Forest (FW-GDL-Soil-01) all ground based equipment should only operate on slopes less than 40 percent, in order to avoid detrimental soil disturbance. Where slopes within an activity area contain short pitches greater than 40 percent, but less than 150 feet length, ground based operations may be allowed as designated by the timber sale administrator. Current activities on the KNF are to establish soil compaction standards for the area allocated to skid trails, landings, temporary roads, or similar areas of concentrated equipment use. Forest Service Manual 2500-99-1 establishes guidelines that limit detrimental soil disturbance to no more than 15 percent of an activity area. Forest Plan soil productivity monitoring results have been historically monitored were reviewed throughout this project area (Kuennen 2006a; Kuennen 2003; USDA Forest Service 2003; and USDA Forest Service 1998). BMP implementation and effectiveness have been monitored and documented since 1988 (Gier 2014). The five-year results from 1992–1997 found less than one percent of the acres surveyed were above the 15 percent threshold, with 77 percent of surveyed areas having less than 10 percent detrimental disturbance. Between 1995 and 2005, none of the units surveyed were above the 15% threshold. Kuennen (2003; 2007a; and Kuennen and Gier 2013) compiled all monitoring data to date, which was used as the basis for soils analysis and specifying design criteria for this project. Results of such activities indicate that all proposed activities are expected to remain below the 15 percent threshold following harvest and related mitigation activities. All management activities would follow the BMPs outlined in Soil and Water Project File and would be consistent with 2015 Forest Plan Standards.

The 2011 KNF Monitoring Summary (USDA Forest Service 2011b) states that monitoring between 1991 and 2011 shows that 95 percent of the BMPs implemented during that time were effective. In summary, the proposed project is consistent with the goals, desired conditions, objectives, and guidelines for all soil resources set forth in the 2015 Kootenai Forest Plan. It should be noted that objectives can be obtained in Soils when temporary roads or system roads become decommissioned therefore returning them to a productive land acreage
as well as when restoration activities such as decompaction occurs which also returns acres back to the productive land base. Refer to below:

Kootenai National Forest Soil Goals, Desired Conditions, Objectives, and Guidelines:

FW-GOAL-SOIL-01:
Maintain soil productivity and ecological processes where functioning properly, and restore where currently degraded. Maintain the physical, chemical, and biological properties of soils to support desired vegetation conditions and soil-hydrologic functions and processes within watersheds.

Response: The Proposed Action would maintain long term soil productivity by ensuring that harvest activities will only occur from NFS lands where soil, slope, and other watershed conditions will not be irreversibly damaged. Recall that soil productivity is spatially statics and productivity in one location does not affect productivity in another location. Therefore, the project would contribute to progress toward meeting FW-GOAL-SOIL-01.

FW-DC-VEG-08:
Down wood occurs throughout the forest in various amounts, sizes, species, and stages of decay. The larger down wood (i.e., coarse woody debris) provides habitat for wildlife species and other organisms, as well as serving important functions for soil productivity.

Response: The Proposed Action would maintain soil productivity through retention of CWD at levels adequate to maintain a healthy ectomycorrhize, and soil micro-organisms community which in turn play an important role in the uptake of nutrients and water by woody plants (Graham et al 1994). Therefore, the project would contribute to progress toward meeting FW-DC-VEG-08.

FW-DC-SOIL-01
Soil organic matter, physical conditions, and down woody debris maintain soil productivity and hydrologic function. Physical, biological, and chemical properties of soils are within the recommended levels by soil type as described in the KNF soil inventory. These soil properties enhance nutrient cycling; maintain the role of carbon storage, and support soil microbial and biochemical processes.

Response: Adequate levels of coarse woody debris will be maintained in order to meet adequate levels required for a healthy ectomycorrhize, and soil micro-organisms community which in turn play an important role in the uptake of nutrients and water by woody plants (Graham et al 1994). Therefore, the project would contribute to progress toward meeting FW-DC-SOIL-01.

FW-DC-SOIL-02
Areas with sensitive and highly erodible soils or landtypes with mass failure are not destabilized as a result of management activities.

Response: There are seven designated “landtypes of concern” on the KNF that should be given additional consideration prior to the introduction of management activities. These are landtypes 102, 112, 325, 351, 365, 370, and 520 (Kuennen 2007d). When viewed at the project area level no landtypes of concern present at the individual Unit level. Therefore, the project would contribute to progress toward meeting FW-DC-SOIL-02.
FW-DC-SOIL-03
Soil impacts are minimized and previously activity areas that have incurred detrimental soil disturbance recover through natural processes and/or restoration activities. Organic matter and woody debris, including large diameter logs, tops, limbs, and fine woody debris, remain on site after vegetation treatments in sufficient quantities to retain moisture, maintain soil quality, and enhance soil development and fertility by periodic release of nutrients as they decompose (refer to FW-GDL-VEG-03).

Response: Coarse woody debris retained on site will physically protect the forest floor and mineral soil from erosion and mechanical disturbances. Retained woody debris is expected to also disrupt airflow and provides shade, which insulates and protects new forest growth and also has significant water holding capacity, making it an important source of moisture for vegetation during dry periods. This decaying woody debris provides nutrients, especially sulfur, phosphorus, and nitrogen, necessary for new plant growth. Therefore, the project would contribute to progress toward meeting FW-DC-SOIL-03.

FW-DC-SOIL-04
Soil organic matter and down woody debris support healthy micorrhizal populations, protects soil from erosion due to surface runoff, and retain soil moisture. Volcanic ash-influenced soil that occur on most of the Forest are not compacted and retain unique properties, such as low bulk density and high water holding capacity, to support desired vegetative growth.

Response: In units where existing historical skid trails already exist, these skid trails will be used to the extent feasible to minimize additional soil disturbance. Effects of temporary roads and skid trails will be temporary due to planned ripping and seeding following harvest activities in areas used for harvest operations to remedy compaction. These activities will help offset disturbance related to harvest activities to soil productivity by allowing previously disturbed soils to re-establish as a productive area capable of producing future natural vegetative cover which in turn may one day be harvested again. As a result, while some increase in detrimental soil disturbance is expected with proposed management activities, all activity areas are expected to remain at/or below the 15% soil quality standards and in the long run soil conditions will be trending towards desired conditions by enhancing secondary stand replacement in areas of diminishing stands. Therefore, the project would contribute to progress toward meeting FW-DC-SOIL-04.

FW-OBJ-SOIL-01
Over the life of the Plan, initiate restoration of 75 to 150 acres not meeting soil quality criteria.

Response: The Proposed Action would help progress to restoring 75 to 150 acres of land over the life of the 2015 forest plan by sub-soil restoration and decompaction activities in areas where soil compaction values either exceed or are very close to exceeding 15% detrimental soil disturbance. Such activities are tentatively planned for Helwick Unit 10. Therefore, the project is designed in accordance with FW-OBJ-SOIL-01.

FW-GDL-SOIL-01
Ground-based equipment should only operate on slopes less than 40 percent, in order to avoid detrimental soil disturbance. Where slopes within an activity area contain short pitches greater than 40 percent, but less than 150 feet in length, ground-based equipment may be allowed, as designated by the timber sale administrator.

Response: The Proposed Action would only operate ground based equipment in areas meeting FW-GDL-SOIL-03 guidelines. In areas where slopes are consistently greater than 40 percent, skyline/cable activities are expected to occur. Therefore, the project is designed in accordance with FW-GDL-SOIL-01.
Soils

FW-GDL-SOIL-02
Coarse woody debris is retained following vegetation management activities per (FW-GDL-VEG-03).

Response: The Proposed Action would move the Analysis toward FW-GDL-SOIL-02 because appropriate levels of coarse woody debris would be retained throughout the planning area and as a result would provide for yearly nutrient inputs through litter fall (Brady and Weil 2002) and long-term CWD as a result of future blow-down and disease. Therefore, the project is designed in accordance with FW-GDL-SOIL-02.

FW-GDL-SOIL-03
On nutrient-limited landtypes, harvesting organics should remain on site for at least 6 months or over a winter season to allow foliage nutrients to leach into the soil, except where site-specific analysis indicates the fuels would present an unacceptable hazard.

Response: The Proposed Action contains only 413 acres of low productivity soils of which only 4 acres will be harvested (unit 17). Following harvest activities post-harvest fuel treatments will not occur until needles have had a chance to return nutrients back to the soil system (>6 months). Therefore, the project is designed in accordance with FW-GDL-SOIL-03.

FW-GDL-SOIL-04
Ground-disturbing management activities on landslide prone areas should be avoided. If activities cannot be avoided, they should be designed to maintain soil and slope stability.

Response: The Proposed Action contains units which have been flagged off and mapped in order to avoid areas containing soil concerns and/or areas prone to landslide activities; therefore, FW-GDL-SOIL-04. Overall this is not relevant to the project.

FW-GDL-SOIL-05
Project specific best management practices (BMPs) should be incorporated into all land management activities as a principle mechanism for protecting soil resources.

Response: The Proposed Action is expected to incorporate project specific Best Management Practices (BMPs) into all land management activities as a principle mechanism for protecting soil resources in the Helwick Project. Therefore, the project is designed in accordance with FW-GDL-SOIL-05.