Summary of Soil Monitoring on the IPNF
1980s to 2010

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1. Introduction

Monitoring for soil disturbance has been performed on the Idaho Panhandle National Forest (IPNF) over several decades. Monitoring can be separated into two main items:

1. **Evaluation of existing conditions –** primarily driven by NEPA project needs. Reviews the current disturbance levels in proposed activity units that may have been harvested by different logging systems, displaying variable soil impacts.

   Main objectives:

   - To determine if proposed units are close to or exceed Regional and Forest Plan standards and need special mitigation that would be incorporated into design criteria and contracts. Includes monitoring of compaction, displacement, rutting, erosion, severe burning, coarse woody debris, and organic matter.

     Data collectors: soil scientist and trained personnel.

   - To assess proposed units for potential hazards (e.g. mass failure, erosive soils) or localized topographical and sensitive soil considerations.

2. **Evaluation of post-harvest conditions –** primarily driven by forest-wide annual monitoring requirements to assure that soil quality standards have been met.

   Main objectives:

   - To determine the conditions and trends of a treated activity area and how the outcome compares to desired conditions. Includes monitoring of compaction, displacement, rutting, erosion, severe burning, coarse woody debris and organic matter.

     Data collectors: soil scientist.

   - To project potential impacts associated with different treatments and logging systems that can be used during future NEPA analysis.
   - To assess if current practices are sufficient or if there is a need for change to management actions.

2. Results

Data from past soil monitoring were compiled from 2004 to 2010 for existing conditions and from 1990 to 2010 for post-harvest observations. Data are also available from 1987 to 1989, but provide only limited information. These years are therefore excluded from many of the averages but included during some of the discussions to provide for a comparison. Findings displayed in this document may aid in the prediction of potential disturbance levels for future projects, and yearly updates should provide continuous trends.

2.1 Existing Conditions

A total of 419 units on the IPNF were monitored between 2004 and 2010 with 188 located on the Central Zone (CZ), 148 on the North Zone (NZ), and 83 on the South Zone (SZ). These numbers do not include proposed activity areas that were field verified by other Forest Service personnel to confirm that a potential unit had never been entered and therefore did not need any soil transects.

Table 1 provides a summary of disturbance ranges for existing soil conditions. The total number of activity areas evaluated was reduced from 419 to 365 because units identified as 100 percent undisturbed were excluded to avoid skewing averages.

Results show that only 4 percent of planned management activities proposed to enter units that currently exceed Regional soil quality standards, which, as identified in R-1 Supplement 2500-99-1 (USDA FS 1999), are those with more than 15% disturbance. When units display over 15% disturbance, a net improvement to soils is required after management activities are completed (USDA FS 1999).

Table 1: *Summary of disturbance ranges for pre-harvest soil conditions in units monitored from 2004 to 2010.*

Pre-Harvest	**CZ**		**NZ**		**SZ**		**Total**	
Range of Disturbance	**# of Units**	**% of total**	**# of Units**	**% of total**	**# of Units**	**% of total**	**# of Units**	**% of total**
0 - 5	122	85	60	42	66	88	248	68
6 - 10	14	10	47	32	8	11	69	19
11 - 15	2	1	31	21	1	1	34	9
>15	6	4	8	5	0	0	14	4
Total	**144**		**146**		**75**		**365**	

How long soil disturbance remains on the landscape has been controversial because lingering impacts would indicate that long-term soil quality has been compromised. Observations from countless field visits and monitoring of units that were harvested dating back to the 1930s have consistently shown that many of the soils are recovering with the assumption that they were impacted at various levels during previous entries. In general, main skid trails and landings can remain disturbed while many side skid trails and other disturbances are improving to levels that may still show some impacts but are not to the detrimental level.

For Table 1 and associated data (not shown), further analysis of previously used logging system details and harvest years would be needed to make more specific and statistically solid conclusions. This is not feasible without a major investment of time and research of past harvest information. A publication by Reeves et al. (2011) has provided a general overview of soil impacts by National Forest for Region 1 and may serve as a reference.

2.2 Post-Harvest Monitoring

Post-harvest disturbance on all districts was monitored between 2004 and 2010 and contributed to the estimation of range of detrimental soil disturbance. A total of 80 units on the IPNF were assessed with 29 located on the CZ, 33 on the NZ, and 18 on the SZ.

Monitoring incorporated units that were harvested with various ground-based equipment, skyline and cable yarding, as well as horse logging. More recent methods, such as combinations of feller-bunchers with skyline yarding, were also included.

Once again, the Regional standard requires that 15% detrimental disturbance within an activity area will not be exceeded. Disturbance levels in Table 2 show that impacts in 42% of the visited activity areas remained below 10%. The harvest methods in these units were primarily horse, skyline, and ground-based winter logging operations.

An increase in disturbance can be observed when numerous pieces of equipment enter a unit for harvest and site preparation, primarily feller-buncher, processor, skidder, and grapple piling combinations. An average 1% to 2% reduction in impacts can be seen when a slash mat is utilized. The bulk of disturbance remains with summer ground-based operations and hovers between 11 to 15 percent.

Table 2: *Summary of disturbance ranges for post-harvest soil conditions in units monitored from 2004 to 2010.*

Post-Harvest	**CZ**		**NZ**		**SZ**		**Total**	
Range of Disturbance	**# of Units**	**% of total**	**# of Units**	**% of total**	**# of Units**	**% of total**	**# of Units**	**% of total**
0 - 5	8	28	4	12	5	28	17	21
6 - 10	5	17	6	18	6	33	17	21
11 - 15	10	34	15	45	4	22	29	36
>15	6	21	8	24	3	17	17	21
Total	**29**		**33**		**18**		**80**	

2.3 Summary of Disturbances

2.3.1 Logging Systems

Soil impact averages were summarized by logging system and decade to compare trends over the past 20 years. It is important to note that the amount of monitoring for each logging type varies so that confidence levels differ due to number of observations. It is often also difficult to piece together exact scenarios for each past sale or unit, which adds to the complications of differences in topography, soils, climate, season, and operator skills. Several combinations of one logging type were merged (Table 3) to provide a generalized average so that numbers provide a broad overview but are not statistically sound.

Table 3 shows a coarse comparison of data from the late 1980s and the following decades, indicating a clear improvement over earlier practices. Stricter BMPs, changing equipment, elimination of dozer piling, and a more conservative and conscious approach to decrease logging impacts are responsible for a reduction on resource impacts.

Table 3: *Summary of disturbance ranges for post-harvest soil conditions in units monitored between 1990 and 2010.*

Logging System	Disturbance Range*	20-year Average %	Last 10 Years Average %	Last 5 Years Average %
Skyline	0-7	1	3	N/A***
Cable	3-5	N/A	4	4
Tractor**	10-80	28	11	13
Feller-buncher**	8-30	14	14	14
Feller-buncher winter	0-19	13	13	13
Feller-buncher & Skyline**	4-8	5	6	5
Cut-to-length**	11-16	N/A	13	12
Cut-to-length winter	5-13	8	8	10
Helicopter	0	0	0	0
All Ground-base total (1980s)	36%			
All Ground-base total (1990-2010)	13%			
All ground-base winter total (1990-2010)	10%			

*incl. data from the late 1980s.
**incl. all combinations of no piling, grapple piling, underburning, no burn, slash mat, no slash mat.
***due to minimal impacts skyline is only monitored visually over the past years.

Cut-to-length (CTL) systems show fewer disturbances due to available slash mats from in-woods processing and reduced equipment passes. Generally only two machines are on the ground, the CTL and a skidder or forwarder.

In comparison, a feller-buncher set-up consists of the feller-buncher (which cannot create a slash mat), a processor, and a skidder or forwarder. The additional equipment, in conjunction with no slash mat for at least one of the machines, appears to be the reason for a slight increase in soil impacts (see Table 3). During whole tree yarding, however, an in-woods processor is not needed and trees are de-limbed at the landing.

Winter conditions generally result in reduced disturbances due to protective snow or frozen ground conditions. However, soil impacts can be the worst when winter conditions are deteriorating and as snow or frozen ground thaws. Summer or winter logging under increasingly wet or saturated conditions leads to elevated compaction, rutting, and puddling, and should be avoided under all circumstances by shutting down operations.

At the end of harvest, the grapple piler is generally the last piece of equipment within a unit. Experienced pilers utilize existing slash mats, work backwards out of the unit, and try to minimize equipment travel on the ground. It is difficult to tease out grapple piling impacts from the overall disturbance after a sale is completed although past observations have shown that piling can add a lot of impacts to an activity area.

2.3.2 Nutrients and Whole Tree Yarding

Harvesting results in the removal of nutrients that have accumulated in the wood and foliage over time. Of concern is the possible loss of potassium in the soil and its effect on forest health, especially the increased susceptibility to insects and disease (Garrison-Johnston et al. 2003) and a possible link between potassium deficiency and the lack of tree resistance to root disease (Garrison-Johnston et al. 2003).

Research (Garrison-Johnston 2003; Garrison-Johnston et al. 2004 and 2007; Moore et al. 2004a; Shen et al. 2001) suggests a complex balance between underlying geology and the natural deficiency of potassium in northern Idaho. Derived primarily from underlying geologic formations, potassium is a product of slow weathering processes (Stark 1979) in comparison to soil nitrogen, which can be replenished more rapidly through nitrogen fixation or atmospheric deposition.

In general, Douglas-fir and grand fir consume and store more potassium than other tree species. Leaving slash for several months on site therefore leaches stored potassium (Baker et al. 1989; Barber and Van Lear 1984; Edmonds 1987; Garrison and Moore, 1998; Jain and Graham 2009; Laskowski et al. 1995; Palviainen et al. 2003), benefiting remaining western larch, ponderosa pine, and western white pine which require less potassium for growth and maintenance.

Whole-tree yarding and removal of treetops can lead to the direct loss of potassium (Morris and Miller 1994). On some sites, ±43 percent of the available potassium is retained in trees, with the remainder being held in subordinate vegetation, forest floor, and soil pools. Within the trees, about 85 percent of the potassium is held in the branches, twigs, and foliage (Garrison and Moore 1998; Jain and Graham 2009; Moore et al. 2004b).

To reduce potential negative effects on long-term soil productivity, whole tree yarding should only occur in commercial thins where remaining trees provide for an ongoing cycling of nutrients. Regeneration cuts should not be whole tree yarded despite favorable economic benefits. Where underlying parent material has a bad or very bad rating (refer to Garrison-Johnston et al. 2007), whole tree yarding should be avoided regardless of silvicultural prescription.

Mastication (the grinding or “chewing” of wood to provide a loose covering for soils) may offer new opportunities for fuel reduction by cutting down submerchantable material and leaving it in the woods. With careful planning and knowledge of onsite stand conditions, it provides a tool that could also reduce grapple piling where material is around 3 inches or less in diameter. Mastication attachments (or small mechanical equipment) is now also considered for pre-commercial thinning. The added impacts from mechanical equipment and unknown existing disturbance levels from past harvest require further evaluation so that activity areas should not be entered without a review, and monitoring should initially be in place to assess impact levels of this method.

2.3.3 Coarse Woody Debris

Management of coarse woody debris (CWD) and organic matter is important to maintaining the soil’s most productive layer. Coarse woody debris is defined as material derived from tree limbs, boles, and roots greater than three inches in diameter and in various stages of decay (Graham et al. 1994). It performs many physical, chemical, and biological functions in forest ecosystems and is also a key habitat component for many wildlife species and for stream ecology. Because CWD is such a valuable part of a functioning ecosystem, a portion of the material must be maintained to ensure that organic matter is recycled for long-term productivity. Nevertheless, in natural systems organic matter fluctuates with forest growth, mortality, fire, and decay.

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. To avoid this, it is important to preserve both fine and CWD on managed sites (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 and provides for the slow, continual release of nutrients.

In forest ecosystems, organic matter can be found in woody debris on the forest floor, in the litter layer as part of the organic horizon, and as soil organic carbon in the mineral soil. The supply, quality, and arrangement of organic matter are also dependent on biologic activity which may vary based on habitat type.

Promoting biologic activity can be used to remediate damaged soils as soil flora and fauna serve to break up compacted soils (Powers 1989) and as it influences many physical characteristics such as soil aggregation, water infiltration, and gas exchange. Soil fungal processes are especially important, primarily mycorrhizal fungi and those associated with organic matter decomposition. The average optimum level of fine organic matter is 21 to 30 percent (Graham et al. 1994), which equates to 1 to 2 inches of surface litter and humus, which provides a good indicator of healthy forest soil (Jain and Graham 2009).

Monitoring of 75 units between 2004 and 2010 (Table 4) shows the general distribution of remaining post-harvest CWD to be heaviest between 6 to 20 tons/acre; however, recommended tons/acre are closely tied to habitat type (Graham et al. 1994; Brown 2002). Table 4 therefore only displays an overview of general amounts left but does not reflect if the recommended amounts were met.

Table 4: *Summary of coarse woody debris monitoring for post-harvest units between 2004 and 2010.*

Coarse Woody Debris tons/acre	# of Units
0 - 5	4
6 - 10	12
11 - 15	21
16-20	11
16-21	6
26-30	6
31-35	6
36-40	4
41-45	3
46-50	0
51-55	0
56-60	2
Total # of Units	**75**

In general, the overall trend has been quite satisfactory with most of the monitored units retaining CWD within their recommended range. The highest retention recommendation (17 to 33 tons/acre) is for moist cedar/hemlock habitats.

Biomass (forest residues that can either be used directly or converted into other energy products such as biofuel) has also been utilized on the forest, primarily on the North Zone. Retention of fines is difficult to measure but is just as important as coarse material. A very close look needs to be taken at underlying parent material, potential nutrient deficiencies due to the site's geology, and proposed silvicultural prescription to ensure that enough material is maintained for long-term productivity if biomass removal is included in management activities.

2.3.4 Prescribed Fire

High-intensity burns that create high soil surface temperatures, particularly when soil moisture content is low, can result in a complete loss of soil microbial populations, woody debris, and the protective duff and litter layer over mineral soil (Erickson and White 2008; Hungerford 1991; Neary and others 2005). Additional deteriorating effects of fires on soils can include a reduction of water infiltration (Wells and others 1979) that contributes to the risk of soil erosion which increases proportionally with fire intensity (Megahan 1990).

Fire-induced soil hydrophobicity is presumed to be a primary cause of observed post-fire increases in runoff and erosion from forested watersheds (Huffman and others 2001). Though hydrophobicity is a naturally occurring phenomenon that can be found within the mineral soil surface, it is greatly amplified by increased burn severity (Doerr and others 2000; Huffman and others 2001; Neary and others 2005).

Burning under controlled conditions of elevated soil moistures reduces the chance of creating hydrophobic soils (Neary and others 2005; Robichaud 2000; Swanson 1981). Past monitoring of post-burn conditions after prescribed fires has shown that soil impacts are minimal when soil moisture conditions are elevated (Niehoff 1985 and 2002). Drier conditions generally increase the risk of losing organic matter that protects the soil from rain splash impacts, erosion, and increased surface heating. A decrease in soil moisture holding capacity can also be expected as duff is removed to expose bare soils.

Over the years, prescribed fire has been monitored on the IPNF. Gathering data prior to the fire, such as soil moisture readings, is challenging because of their need to be taken right before prescribed burning occurs. Additional details, such as fuel information, are equally important. The following compilations in Tables 5 through 7 show a summary of results for several prescribed fires.

The most detailed results were gathered for three units of the High Bridge Outlet (HBO) sale on the NZ between 2009 and 2010. Soil moistures consequently were not the main driver in the outcome of prescribed fire on these units but appear to be critical when fuel loads are high and fuel moistures are low. The requirement for elevated soil moisture levels should therefore be strongly considered when burning under these conditions takes place.

Table 5: *Background information of underburned units on the HBO sale.*

Unit #	Harvested (Burned)	Soil Moisture (Average)	Fuel Moisture (10 hr. fuels)	Slash Cover	Slash Type	Duff Depths (inches)	Other
12	Winter '07-'08 (10/6/2009)	31% - 39% (34%)	11 – 12%	Pockets of slash	LP/DF/L/GF	NA	2-4 mph wind
13	Winter '06-'07 (9/27/2009)	18% - 33% (27%)	6 – 8%	Continuous thick cover	LP/L	1¾ to 2¼	3-6 mph gusting to 9 mph
14	Winter '06-'07 (9/27/2009)	8% - 14% (11%)	8 – 9%	Light, less continuous thinner cover	LP/GF/S/L	¾ to 1½	2-4 mph wind

*GF – Grand fir; DF – Douglas-fir; L – Larch; LP – Lodgepole; S – Spruce

Table 6: *Summary comparison of monitoring details for several prescribed burns.*

Disturbance (%)			
Unit	**Class 0**	**Class 1**	**Class 2**
HBO #12	40	45	15
HBO #13	6	78	15 (4% from burn)
HBO #14	34	52	14 (1% from burn)
Brushy Mission #6	72	18	10 (5% from burn)
Organic Matter (%)			
	<¾ inch - low	¾ to 1¾ - optimum	>1¾ - high
HBO #12	58 (2% bare from burn)	36	2
HBO #13	93 (17% bare from burn)	7	0
HBO #14	95 (14% bare from burn)	5	0
Brushy Mission #6	40 (8% bare from burn)	50	2
Canfield #5*	54	42	4
Canfield #6*	50	38	12
Coarse Woody Debris			
HBO #12	10.8 t/ac		
HBO #13	13.0 t/ac		
HBO #14	6.7 t/ac		
Brushy Mission #6	11.7 t/ac		
Canfield #5	15.0 t/ac		
Canfield #6	9.0 t/ac		
Flatmoore #65	10.1 t/ac		

Class 0: Undisturbed – no evidence of past management activities; no depressions or wheel tracks; forest floor intact and present; litter and duff not burned
Class 1: Faint wheel tracks or slight depressions evident <2 in. deep. Forest floor present and intact; no surface soil displacement; minimal to no mixing of surface soils with subsoil; burning light; compaction concentrated between 0 to 4 in.; platy and massive structure restricted to 0 to 4 in.; platyness non-continuous.
Class 2: Wheel tracks or depressions evident >2 in. deep; Forest floor partially intact or missing; surface soil partially intact or missing and maybe mixed with subsoil; burning moderate to high; compaction concentrated >4 in. deep with platy and massive structure; lack of fine roots but maybe larger ones. Results in this class are considered detrimental.
Detrimental soil disturbance cannot exceed 15% of an activity area – R1 Soil Quality Standards.
*Bare soils were not separated out within the "low" category.

Table 7: *Summary of burn severity for several monitored prescribed fires.*

Unit #	Burn Severity %			
	Unburned	**Light**	**Moderate**	**Severe**
HBO #12	56	42	2	0
HBO #13	9	84	3	4
HBO #14	35	63	1	1
Brushy Mission #6	93	1	1	5
Canfield #5	76	22	2	0
Canfield #6	66	32	2	0
Flatmoore #65	72	12	2	0

Prescribed burning should be done during times when the majority of soil moisture in the upper surface inch of mineral soil is 25+ percent by weight; or 60 to 100 percent duff moisture; or when post-burn conditions would result in no more than 25 to 30 percent bare soils (excluding natural conditions) within an activity area (burn unit).

The desired outcome includes retention of organic matter (generally not much less than ¼ inch) that protects the soil from rain splash impacts, erosion, a decrease in soil moisture holding capacity, and increased solar surface heating, especially on south-facing slopes and in shrub fields. Removal of organic material is of greatest concern on south-facing slopes, exposed ridges, breaklands, and along slopes that still display shrub stages after the 1910 fires.

For landscape sized projects, recommendations suggest utilization of extended burn periods so that only portions of the watershed are incrementally impacted over the intended time frame. This should allow burned areas to recover and potential sediment movement or delivery to be minimal, especially if riparian buffers are maintained.

When prescribed burning is utilized after re-contouring system or temporary roads, the slash and organic material that has been incorporated into the road rehabilitation should not be burned.

2.3.5 Main Causes and Mitigation of Soil Impacts on the IPNF

The key to reducing soil disturbance is to avoid impacts to begin with. Taking care of the soil resource during initial entry or follow-up treatment ensures regulatory compliance, a more rapid recovery, and generally a pleasant visual and productive landscape. Equipment operator expertise and close oversight by a knowledgeable sale administrator are crucial.

Skid Trail Spacing - Based on observations and monitoring results, the most common contributor to elevated disturbance levels is skid trail spacing and associated compaction. With a steady move towards fully mechanized logging practices, trail spacing is generally far less than 100 feet and is dictated by equipment reach, topography, and slope gradient.

Careful review of the operator suggested skids, enforcement of dedicated trails, as well as incorporation of all existing legacy trails and disturbances can eliminate many unnecessary impacts. Skid trails that are spaced less than 20 to 40 feet apart (except where converging), are side by side, or are next to existing old spurs or roads have been encountered and should not occur.

When whole tree yarding is combined with mechanical equipment such as feller-bunchers and skidders, there is no slash mat available. If units already contain elevated levels of legacy impacts, such equipment combinations and their additional disturbance are not desirable. Circumstances such as these are just one example that amplifies the need to properly plan ahead during the analysis and planning stages of a timber sale, primarily through on-site field visits by the interdisciplinary team and through individual reconnaissance.

Travel Patterns - Another great impact stems from sidetracking or turning equipment, especially along slopes. Rutting and displacement can be tremendous, often mixes less fertile substrate with the irreplaceable ash soils, and leaves visible scars that are difficult to heal over. Though it is not always possible to move about in relatively straight lines, sidetracking along slopes and tight turns should be avoided whenever possible.

Grapple Piling - Grapple piling has been an issue during several reviews. Though skids may be laid out nicely during the initial harvest, piling equipment often zigzags all across a unit and can leave behind an array of disturbances.

Steep Slopes - Harvest equipment is usually restricted to operate on slopes <40%. Past monitoring has encountered that equipment working on slopes that exceed >45% can result in deep (1-2 feet) ruts and added compaction. The logging system needs to match the landscape and operators should avoid adverse travel.

Lack of Ground Verification - When proposed activity areas are not properly ground-truthed to ensure that logging systems match the topography and that slopes and slope lengths are able to accommodate mechanical equipment, negative impacts to soils and other resources as well as undesirable economical costs are possible. Maps and GIS provide essential tools for planning but should not be solely relied on without actual on-site visits.

Lack of ground verification during the initial analysis has created unnecessary work and costly expenses in the past and is an ongoing concern as dwindling budgets and personnel present continuing challenges. Spending time and funds up front to thoroughly think projects and prescriptions through are essential for successful completion of projects. This includes up front involvement of sale administrators, clear communication with ID Team members, and annual reviews of projects by all to learn from past successes and mistakes.

2.3.6 Road Rehabilitation and Decompaction

Roads are currently the primary source of erosion and sediment production on the IPNF. The dominant processes are surface erosion from bare soil areas of roads, including the cut slope, fill slope, and travel way. Revegetation of cut slopes and fill slopes is often difficult due to lack of soil moisture, organic material, low productivity potential, and desiccation of seeds and seedlings, especially on south-facing slopes. On moist slopes, revegetation efforts are more successful since erosion of road cut slopes and fill slopes is generally lower.

Road erosion and sediment yield usually decline after construction (Jones 2000; Switalski et al. 2004) but can provide a chronic, long-term source of sediment to streams within a project area. Periodic large pulses of erosion may occur during intense water yield and overland flow events in interaction with road drainage systems.

Roads and landings that remain on the landscape for future use (system roads) are considered irretrievable effects on productivity as these lands become “dedicated” to the permanent transportation system. Temporary roads (i.e., only needed for a project) have detrimental effects initially. Although rehabilitation through decompaction and/or recontouring cannot assume complete reversal to natural conditions, efforts initiate a long-term recovery process.

Restoration of compacted surfaces, such as roads, landings, and skids trails provide net improvements to soil productivity. This is accomplished through decompaction, addition of organic material, revegetation of bare areas, and weed control. Improvements in hydrologic function initiate a recovery process that otherwise may be prolonged as soil compaction persists.

Monitoring of road and trail surfaces consist of an involved process of measuring bulk densities at numerous locations and is often complicated by coarse material that is difficult to sample. Decompaction efforts from several sites on the IPNF have shown to be successful in improving approximately 50 to 60% of the area when compared to adjacent compacted areas. A conservative value of 30% is therefore used when calculating potential net-improvements to soils from decompaction.

However, decompaction is not always an option to improve a site. Shallow soils, underlying bedrock, less fertile subsoils close to the surface, tree roots, soil texture, and overall feasibility should be considered when making this expensive decision. If more harm than good is done by mixing soils, damaging roots of leave trees, or re-sealing surfaces due to high clay content (primarily a concern around the Coeur d'Alene area below 3,200 ft., in heavy soils of old lakebeds, or in some soils with little to no ash influence), decompaction or subsoiling should not be utilized.

3. Summary

The soils, favorable climate, and differing landscapes of the IPNF have provided the forest with a wealth of vegetation and growing conditions. When utilization of forest products and other management activities include the health of all natural resources, they remain sustainable and offer an ongoing opportunity of beneficial uses. Soil monitoring on the IPNF shows that trends remain favorable and that a lot of good work can be accomplished without compromising the environment. Conversely, there are areas where improvements can and need to be made.

Impacts do occur but time has shown to provide recovery and the resilience of systems offers windows for sound sustainable management. In the meantime, it takes continuous conscious efforts and willingness by leadership, program managers, specialists, and field personnel to try new approaches, improve old practices, as well as knowing when to refrain from adverse activities to ensure that soils will retain their productivity on the IPNF.

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