Soil and Water Question 1 - Soil Productivity

Goals: Maintain soil productivity and minimize soil erosion from land-disturbing activities. Minimize sediment transported to streams from land-disturbing activities. Maintain and restore the biological, physical, and chemical integrity of Tongass National Forest waters.

Objectives: Attain Alaska Region (R-10) Soil Quality Standards. Attain State of Alaska Water Quality Standards.

Background: Implementation of Soil and Water standards and guidelines is necessary to maintain soil productivity and water quality. The Soil and Water standards and guidelines are implemented as Best Management Practices (BMPs) described in FSH 2509.22. Region 10 Soil Quality standards are documented in FSM 2554. Soil conservation practices are used to ensure that ground-disturbing activities will meet the R-10 Soil Quality Standards. Typical soil conservation practices include log suspension requirements in timber harvest units and the use of full-bench and end-haul road construction techniques on landslide-prone terrain. Implementation monitoring evaluates whether or not soil conservation practices were required and implemented. Effectiveness monitoring determines whether or not the soil conservation practice used kept the ground-disturbing activity within the R-10 Soil Quality standard.

The State of Alaska Water Quality Standards set standards for chemical, physical, and biologic parameters of waters on National Forest System Lands. The Forest Service in Region 10 uses Best Management Practices and site-specific prescriptions to meet State of Alaska Water Quality Standards when implementing ground-disturbing activities on National Forest System lands.

Soil and Water Question 1: Are the soil conservation practices implemented and effective in meeting Alaska Regional Soil Quality Standards and maintaining soil productivity?

In 1993, the Tongass provided minimum size criteria for all detrimental soil conditions listed in the 1992 Regional Soil Quality Standards. The minimum size criteria were based on the best available information at the time, and included very small soil disturbances. Many resource specialists believe small soil disturbances currently considered detrimental are not detrimental to long-term soil productivity. Soil scientists believe it is time to validate the Tongass' minimum size criteria interpreted from the Region 10 Soil Quality Standards. The 2008 Forest Plan allows for this type of "validation" in the effectiveness monitoring question when it asks if soil conservation practices are effective in maintaining soil productivity.

The Region 10 Soil Quality Standards received minor revision in 2006 and soil quality monitoring on the 89-94 long-term timber sale was completed in 1997. As a result of these changes, the soil quality monitoring protocol was also updated in fiscal year (FY) 2009 to eliminate reference to the 89-94 long-term timber sale monitoring and 1992 Soil Quality Standards.

In FY 2007 Tongass Soil Scientists initiated a monitoring plan designed around "validation" of the Tongass' interpretation of the Region 10 Soil Quality Standards. Field work was completed in 2011 and FY 2012 was the report writing year.

Monitoring Results

The central concept behind Soil Quality Standards is that they represent soil conditions that are detrimental to long-term soil productivity. If soil productivity is affected the ability of the soil to support the typical growth rates of the desired vegetation will be affected. The best time to identify changes to forest vegetation growth is after several decades have passed.

The FY 2012 monitoring report (Landwehr et. al. 2012) summarizes data collected in 34 young-growth stands ranging in age from 10 to 63 years. Fifteen of the stands were more than 50 years old and represent some of the oldest young-growth on the forest. The group of stands were spread across the forest with representation from Yakutat, Petersburg, Wrangell, Ketchikan, Craig, and Thorne Bay Ranger Districts. Methods included remonitoring soil disturbance in stands where soil disturbance was measured 15 years ago, measuring soil disturbance and duff thickness in young-growth stands more than 50 years old and adjacent unharvested areas, and revisiting stands more than one year old with photo documentation of severe soil disturbance during yarding operations. We also took soil disturbance and woody debris measurements in stands with heavy woody debris accumulations.

Some of the key findings described in the 2012 report include:

Monitoring soil and vegetation in 15 year-old stands

Many small soil disturbances documented shortly after harvest were not evident after 15 years of recovery. The longevity of soil disturbance on the landscape is related to type of soil material exposed, landscape position, and repeated disturbance from natural sources. The definition of a detrimental soil condition needs to take into account soil type, landscape position, and potential natural disturbance agents that may prevent natural recovery of the site.

In areas where detrimental soil conditions still exist 15 years after timber harvest the soil left in these areas consists of cobbly and/or dense subsoil material or bedrock and the site is in a landscape position where the exposed soil does not receive fine soil material or organic matter from adjacent areas. Heavy rainfall, wildlife traffic, snow avalanching and/or snowmelt continue to disturb or erode the site, preventing natural recovery.

Grass seeding on nutrient poor substrates on steep slopes can arrest erosion and help the site trap fine sediments and seeds of woody plants and provide a seedbed for woody plant establishment. Conversely, on disturbed areas in organic soil or richer mineral soils, grass seeding may retard growth of woody plants through grass stand dominance of the site.

Many small soil disturbances, less than about 25 square feet in size are not identifiable after 15 years of recovery and likely not detrimental to woody plant growth even on relatively poor soils.

The Tongass' interpretation of the minimum size requirements for detrimental puddling, lack of ground cover, burned areas, altered wetness, and compaction could be changed from 1 foot to 25 square feet with very little risk of missing any detrimental soil conditions. Small soil disturbances (less than 25 square feet) on landslide prone terrain have contributed to landslides on the forest. Soil Quality Standards need to consider the landscape position for contributing area and other slope stability attributes.

Monitoring soil and vegetation in 50 year-old stands

Productive soils with relatively nutrient rich subsoil horizons may tolerate more severe and more extensive areas of soil disturbance before a change in desired vegetation growth is obvious. Limestone soils in particular have a higher nutrient availability at depth when compared to soils of mixed mineralogy on the Tongass. Severe soil displacements (where bedrock or dense till are exposed) on limestone still resulted in the loss of the ability of the site to produce the desired vegetation at the desired growth rates. In the absence of red alder severely disturbed sites support salmonberry, ferns, elderberry and, depending on site conditions devil's club.

Soil displacements less than about 100 square feet in size were rarely identifiable in highly productive 50 year-old stands (with the notable exception of coarse textured gravelly outwash soils discussed below). Most detrimental soil conditions noted were 12 to 14 foot wide skid trails that were tens of feet in length.

Soil and Water 1 Picture 1. Tractor skid trail in 54 year old young-growth on limestone soils on Kosciusko Island. Canopy closure is almost complete and the trails are difficult to identify on recent air photos of the stand.

In tractor logged areas soil displacements from tractor skid trails can occupy more than 10 percent of the stand. On productive sites with nutrient capital at depth and where erosion or mass wasting is not a concern, the minimum size of a detrimental soil condition is likely in excess of 100 square feet. In the seven tractor logged stands we monitored detrimental soil conditions from tractor skid trails averaged seven percent of the stand. In the eight cable-logged stands monitored detrimental soil conditions averaged less than two percent of the stand.

Bulk density samples in the 50-year old stands and in recent tractor logging indicates soil compaction is not an issue in these stands. Coarse textured soils with high organic matter content and low natural bulk density are the main reasons soil compaction is not a concern in most Tongass soils.

Detrimental soil conditions in 50-year old young-growth stands were primarily soil displacements more than 100 square feet in size and soil erosion. Soil displacements occurred on primary tractor skid trails and cable yarding corridors, especially between spar trees and the yarder. Typically these displaced areas were ten feet wide or wider and tens of feet long. Soil erosion often occurred for several years after timber harvest in the displaced areas on sloping ground as evidenced by small gullies and ephemeral streams in these areas. By age 50, soil erosion is almost entirely arrested.

On highly productive soils on limestone canopy closure has occurred over the skid trails by age 50. On lower productivity conifer dominated sites or on gravelly outwash soils canopy closure has not occurred over the skid trails or the canopy is red alder. On gravelly outwash soils moderately disturbed sites (where upper soil horizons were mixed by yarding activity) there is a noticeable difference in desired vegetation composition and density. Based on these results soil disturbance should be minimized on young gravelly

outwash soils with little nutrient capital at depth. More work needs to be done to determine if the difference in desired vegetation growth is the result of delayed regeneration or changes in soil nutrient availability.

Soil and Water 1 Picture 2. Tractor skid trail and landing in 52 year old young-growth at Thomas Bay. Outwash soils with little nutrient capital at depth. Canopy closure is not achieved at age 52.

The absence of a red alder seed source in the vicinity of the many of the 50+ year old stands resulted in dense conifer growth. If an alder seed source is present slight or moderate severity soil disturbance over extensive areas can create an alder dominated stand or mixed alder/conifer stand. Without intervention red alder will persist in these stands for more than 40 years. Where an alder seed source was present during the initial harvest (Vank Island and Luck Lake) the stands are either alder dominated or include a high component of alder today.

Soils in unharvested limestone stands have thicker duff layers than soils in adjacent, comparable harvested stands. It is possible that timber harvest helped to reduce duff thickness through either microbial stimulation or mechanical compaction by harvest or snow load. The duff reduction may positively or negatively affect soil productivity depending on the mechanism of reduction. More work needs to be done to understand why the duff layer is thicker on soils over limestone in unharvested stands than in harvested stands. Since fungi are the primary decomposers, woody debris and fungal inventories may be logical starting points.

Soil and Water 1 Picture 3. Alders occupying a tractor skid trail in a 60 year old stand on Vank Island. Compare with pictures 1 and 2 where the soil was heavily disturbed but no alder seed source was present.

Soil and Water 1 Picture 4. Left: An A-frame yarding corridor in the Flicker Creek stand. Soils are shallow to limestone bedrock. Right: An A-frame yarding corridor in the Deweyville stand. Dense till underlies the yarding corridor at this site. Both stands are more than 50 years old.

Soils in unharvested limestone stands generally have thicker duff layers than soils in unharvested stands on soils with mixed mineralogy. Possible explanations for this phenomenon include differences in recalcitrance of leaf litter caused by different plant associations growing on the unharvested limestone soils. Many of the unharvested limestone soils experience catastrophic windthrow every 200 years or more leading to dense, even-aged conifer stands with a moss understory. The moss understory likely decomposes at a slower rate than litter from a blueberry and herbaceous understory. More work needs to be done to understand why the duff layer is thicker on soils over limestone in unharvested stands than in other unharvested stands on soils with mixed mineralogy.

In the Vank Island stands the duff thickness is generally thinner than other stands measured due to the high amount of deciduous vegetation in these stands. Loess soils on Vank Island may also be better invertebrate and microbe habitat than coarser textured soils. For example, earthworms were more common in the loess soils on Vank Island than in other soils sampled in this monitoring and may be playing a role in duff reduction.

Stands with severe soil disturbances

Shovel ruts were still present after 20 years of recovery. Shovel ruts tend to either improve soil drainage by carrying water away from the site or impede soil drainage by interrupting preferential flow paths in the soil or by intercepting the seasonal water table in the soil. Seasonal water tables are common atop the dense till that occurs in many soils at variable depths. Preferential flow paths occur at various depths in the soil and help the soil process water and prevent erosion or ponding of water. Rutting that mixes soil horizons, intercepts seasonal water tables, or disrupts preferential flow paths in the soil should be avoided. Preferential flow paths typically occur atop the dense till and less commonly atop the Bh horizon or just under the duff layer. Where soil drainage is improved soil productivity generally increases and where soil drainage is impeded soil productivity is reduced. Rutting should avoid interception of seasonal water tables or disruption of preferential flow paths or seasonal water tables, especially on soils that are not well drained.

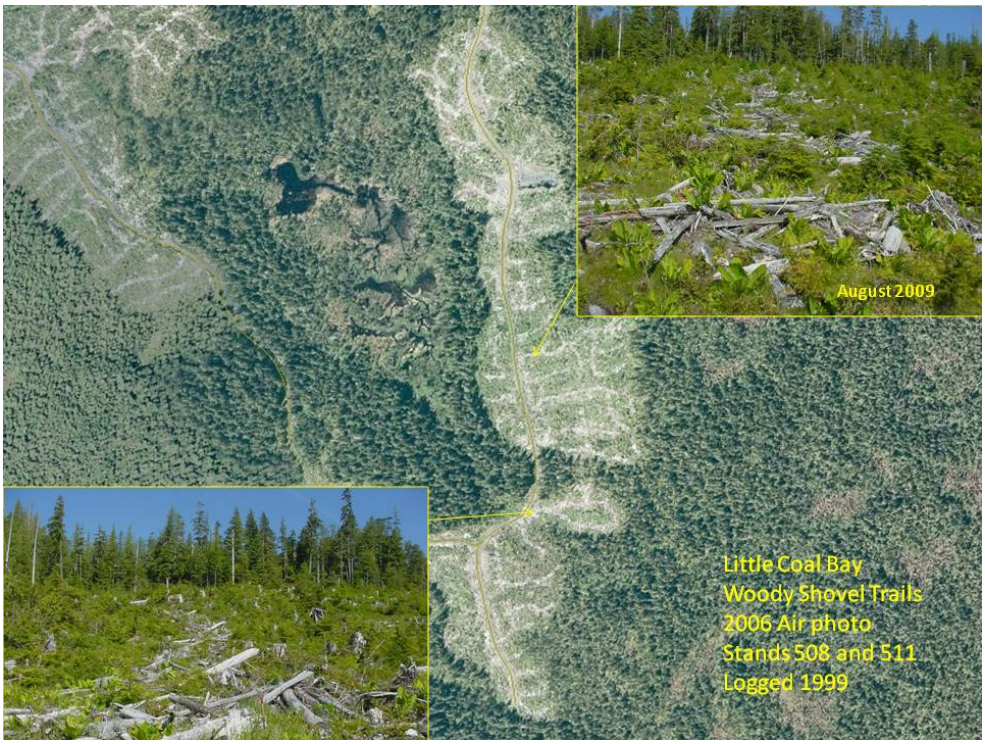
Soil and Water 1 Picture 5. Shovel rut in Canyon Spur harvest unit is still evident and well defined after 20 years

Areas of soil displacement greater than 100 square feet in size generally resulted in reduced growth rates and different plant communities than adjacent undisturbed sites (picture 6). On gravelly nutrient poor soils the effects of soil displacement are more pronounced and appear to be longer lasting.

Soil and Water 1 Picture 6. Summary of photo documentation of soil disturbance at Cap Island, 1991 to 2009

Stands with dense slash accumulations

Dense slash mats can negatively affect conifer regeneration and growth but the slash mat has to be pretty dense. We monitored four 10+ year old stands at Little Coal Bay where slashed shovel trails are easily visible from the air (picture 7). In the Little Coal Bay harvest units the slash mat does not appear to be dense enough to inhibit regeneration and growth of the desired vegetation. In the Gonzo Timber Sale and on the Old Naukati Skid Trail the slash mats and corduroy skid trails appear to be affecting regeneration and growth of conifers. Based on those observations the recently constructed Winter Harbor shovel trails and the Commercial Thinning Study Skid Trails will negatively affect the regeneration and growth of conifers and other desired vegetation. Slash mats can easily be broken up or fluffed by the shovel operator during the last pass out of the unit.



Soil and Water 1 Picture 7. A 2006 aerial view of stands 508 and 511 near Little Coal Bay. Woody shovel trails are easily visible from the air.

Soil and Water 1 Picture 8. Dense layers of fine slash on the commercial thinning skid trails will likely inhibit soil respiration, conifer regeneration and growth.

Soil and Water 1 Picture 9. Slash penetration into the upper 25 centimeters of soil on a skid trail at Maybeso Plot 4 (left). The original corduroy skid trail used to access the Naukati stand 63 years ago (right).

The 2012 report also includes a list of recommendations regarding assessing detrimental soil conditions in young-growth stands, revising soil quality standards and the Tongass' interpretation of them and future soil monitoring needs.

Soil quality monitoring of Wrangell Island shovel yarding

In 2012 Tongass soil scientists also collected soil quality monitoring data on two timber harvest units that were shovel logged on Wrangell Island and four 40 year-old young-growth units proposed for treatment in the Big Thorne Timber Sale. The data collected from the four Big Thorne young-growth units will be presented in that FEIS.

The shovel yarded portions of units four and eleven of the Backline Timber Sale were monitored in July 2012. Shovel yarding in both units included slopes ranging up to 45 percent gradient. Typically shovel yarding is conducted on slopes less than 35 percent gradient. Sixty soil disturbance transects were completed in the two units. Since this is one of the first opportunities we have had to monitor shovel yarding on steeper slopes, the transect data was stratified by slope. On slopes less than 25 percent gradient soil disturbance averaged less than three percent. On slopes over 35 percent gradient soil disturbance averaged ten percent. The increasing soil disturbance with increasing slope was also reported by Landwehr and Silkworth in 2011 on the Staney Wildlife Gaps Project. On steeper slopes many of the soil disturbances consisted of ruts to dense till or bedrock or soil displacements caused by the shovel operator using soil to create a more level surface to operate on. Soil disturbance caused by shovel operation is very operator dependent. Shovel operators on the Backline Timber Sale on Wrangell Island are relatively inexperienced, especially on steeper slopes. Observations on the Logjam Timber Sale indicate that some operators can successfully negotiate slopes of 35 percent with minimal soil disturbance.

Soil and Water 1 Picture 10. Shovel yard trail on 25 to 35 percent slopes well drained soil, shallow to bedrock. Very little soil disturbance. Unit 4 Backline Timber Sale, Wrangell Island.

Soil and Water 1 Picture 11. Shovel trail excavation, stumps pulled to build level trail nutrient rich soil is gone and bedrock exposed over several hundred square feet. This is a detrimental soil displacement; slopes about 40 percent; Unit 11, Backline Timber Sale, Wrangell Island.

Evaluation of Results

Over the past twenty years, Tongass soil scientists have collected soil quality monitoring data in recently logged stands using the same protocols and definitions of detrimental soil conditions. The data summarized in the 2012 report indicates that many of the soil conditions, previously identified as detrimental to growth of trees and desired vegetation, are not detrimental. Therefore, the estimates of detrimental soil conditions the Tongass uses for environmental impact analysis could be adjusted slightly or refined. The 2012 report shows that the definition of a detrimental soil condition needs to consider soil type, landscape position, and potential natural disturbance agents that may prevent natural recovery of the site. The current Region 10 soil quality standards are a one size fits all standard that should be adjusted based on the findings in the 2012 report.

Existing soil conditions need to be documented in young-growth stands proposed for treatment. The Landwehr et al. 2012 monitoring report provides a list of recommendations for future soil monitoring work in young-growth stands. As forest management continues to transition to more young-growth management, the findings and recommendations from Landwehr et al. 2012 should be used to guide soil monitoring efforts.

The monitoring of the shovel yarding on the Backline Timber Sale indicated a need to restrict inexperienced shovel operators to slopes less than 30 percent gradient until they gain experience to operate on steeper slopes. Additional soil quality monitoring should occur on areas shovel yarded on slopes over 35 percent gradient.

Action Plan

The data and recommendations in the 2012 report will be used for young-growth management projects and designing future monitoring efforts for the soil monitoring program. The Tongass interpretation of Regional Soil Quality standards could be revised based on the results and recommendations described in Landwehr's 2012 monitoring report. Based on the work on Wrangell Island, additional soil quality monitoring should occur on areas shovel yarded on slopes over 35 percent gradient.

See Soil and Water Question 1 Appendix – Soil Quality Standards for more information in response to this monitoring question.