Soil Resource

Introduction

Monitoring and evaluation are critical elements in determining whether the Forest is meeting its obligation for protection of the soil resource. It is only through monitoring and evaluation that we can determine effects that may be occurring to soils from management activities and other influences, and we can adjust our management practices accordingly to keep those effects within acceptable levels and ensure that we maintain or improve soil quality and productivity.

2008 Program Accomplishments

The Program accomplishments for 2008 included:

- Budget and work planning, including out-year planning.
- Analyzing effects for a variety of Forest projects.
- Completing scheduled soil surveys.
- Testing newly developed Soil Quality Management standards and Detrimental Soil Disturbance protocols for the WO and Region 9
- Additional projects described below.

SOIL SAMPLING AND UPDATE INVENTORY SOIL/AIR PROJECTS WITH THE USDA-NRCS SOIL SURVEY DIVISION

In 2007-2008, the Soil Resource Inventory was updated by an additional 1,875 acres through the Tucker County Soil Survey Update, conducted by the USDA Natural Resource Conservation Service (NRCS). NRCS assisted with sampling events in Lower Williams River Watershed.

The Soils Program also lost the Assistant Soil Scientist position during the 3rd quarter. As part of an agreement, NRCS offered assistance by providing an interim Resource Soil Scientist. This partnership proved to be successful in trading of services and funding.

Accomplishments also included the monitoring and evaluation efforts described below.

Monitoring and Evaluation

FOREST PLAN MONITORING ITEMS FOR THE SOIL RESOURCE

The 2006 Monongahela National Forest Land and Resource Management Plan (Forest Plan) has two monitoring items in the Chapter IV Monitoring Matrix that are directly related to soils:

Item 31. Is soil detrimental disturbance associated with land management activities below the 15% soil productivity loss threshold?

Item 32. Is acid deposition affecting soil productivity loss, and if so, is it affecting land sustainability?

These monitoring items, in turn, can be used to show how the Forest is meeting management direction in Chapter II of the Forest Plan. Specifically, that direction includes Goals SW01 and SW02, Standards SW03, SW04, SW06, SW07, and SW08, and Guidelines SW10, SW11, SW12, SW13, SW14, SW15, SW16, and SW18.

Monitoring activities in FY 2008 related to Items 31 and 32 are described below.

ITEM 32. Is acid deposition affecting soil productivity loss and if so, is it affecting land sustainability?

Soil water and stream acidification are real phenomena that have been shown to occur in West Virginia. Long-term, increasing losses of base cations to stream water due to ambient acid deposition have been documented in stream water on a control watershed in the Fernow Experimental Forest, which is located in the Monongahela NF (Edwards and Helvey 1991). Other watersheds on and near the Fernow Experimental Forest, which have been artificially acidified with sulfur and nitrogen to determine effects on soils and stream water, have shown mobilization of base cations in soil and consequent leaching to stream water and substantial reductions in the acid-neutralizing capacity of soil and water (Edwards et al. 2002a, 2002b).

Since 1995, intensive soil data collection has occurred in various locations across the Forest, including comprehensive studies in the Otter Creek Wilderness, North Fork of Cherry River watershed, and Lower Williams River watershed. These efforts began to establish baseline soil chemistry data across the Forest, especially in areas assessed by the Soil Nutrient Sensitivity Map to be highly sensitive to acidification (Connolly et al. 2007). Through 2006, more than 600 soil samples have been collected across varying soil types, landscape positions, and aspects, and they have been analyzed for physical and chemical characteristics. Preliminary results show that soils in sensitive areas are affected adversely by acid deposition. Base saturation values are often below 15 percent in areas where base-poor geologies exist (Jenkins 2002, Schnably 2003, Desert Branch EA Soil Resource Report 2003, Cherry River EA Soil Resource Report 2004, Lower Williams River EIS 2009), and Calcium to Aluminum (Ca:Al) ratios are less than 1.0 for soils found on ridge tops and benches of these same areas (Desert Branch EA Soil Resource Report, Cherry River EA Soil Resource Report, Lower Williams River Soil Resource Report). Some south-facing cove soils have soil aluminum levels that might indicate toxicity for vegetation.

In FY 2008, several projects were completed to provide additional soil chemistry data and monitoring information. A multi-year study was completed that provided soil, foliar, and vegetation health monitoring data to the Forest-wide assessment, and two small localized watershed soil sampling events occurred in the Anthony Creek watershed and in the Lower Williams River project area.

Monitoring for Item 32:

In 2008 a multi-year study was completed in cooperation with Virginia Tech State University, USFS Northern Research Station (Forest Health and Monitoring), and USDA- Natural Resource Conservation Service. This study resulted in the following thesis.

> ***Acid deposition effects on soil chemistry and forest growth on the Monongahela National Forest,*** by PATRICIA E. ELIAS, Virginia Polytechnic Institute and State University; Approved: James A. Burger (Chair), Mary B. Adams, Richard G. Oderwald, Stephen P. Prisley, Lucian W. Zelazny.

The following is an excerpt from the abstract of that study, which highlights findings and recommendations for the MNF.

> **"**To address the needs of MNF managers we used Forest Inventory and Analysis (FIA) sites to evaluate forest growth patterns on the Forest and determined the relationship between growth and key indicators of soil acidity. Furthermore, we used those relationships to create a map of site resistance to acidification across the MNF. To further develop a monitoring scheme we assessed two soil sampling protocols and two soil analysis methods for their suitability for monitoring AD-related changes in soil chemistry. Additionally, we evaluated the utility of dendrochronological and foliar sampling as AD-specific monitoring methods.
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> Across all FIA sites on the MNF periodic mean annual volume increment (PMAVI) ranged from -9.5 $m^3ha^{-1}yr^{-1}$ to 11.8 $m^3ha^{-1}yr^{-1}$, suggesting lower-than-expected growth on two-thirds of the sites. Growth was compared to soil indicators of acidity on 30 FIA sites. In the surface horizon, effective base saturation (+), Ca concentration (+), base saturation (+), K concentration (+), Fe concentration (-), Ca/Al molar ratio (+), and Mg/Al molar ratio (+), were correlated with PMAVI ($p \leq 0.1$). In the subsurface horizon $pH_{(w)}$ (+), effective base saturation (+), Al concentration (-), and K concentration (-) were correlated with PMAVI. Site resistance to acidification was mapped based on site parent material, aspect, elevation, soil depth, and soil texture. There was a significant ($p \leq 0.1$) positive correlation between PMAVI and a resistance index developed using five soil and site factors. Resistance was also compared with key soil indicators of AD-induced decline on 28 sites across the forest, and pH, effective base saturation, and Al content were found to be the best indicators related to resistance index. Resistance index was used to create a map of the MNF, of which 14% was highly resistant ($RI \geq 0.7$), 57% was moderately resistant ($0.7 > RI > 0.45$) and 29% was slightly resistant ($RI \leq 0.45$).
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> The first of our monitoring program evaluations compared soil sampling and analysis methods on 30 FIA plots. Analyses of variance showed that soil pH, effective base saturation, Ca/Al molar ratio, and sum of bases varied significantly with sampling protocol. We also compared lab analyses methods and found that if sampling by horizon, a linear relationship can be used to estimate Ca/Al_{SrCl2} ratio using NH_4Cl extractions. The second monitoring approach evaluated the utility of a northern red oak (*Quercus rubra* L.) dendrochronology on two FIA plots. This analysis suggests that pollution on the MNF caused a decrease in growth rate during the 50-year period from 1940 to 1990. There were no differences among ring width increment and basal area increment between the two sites. From 1900 to 2007 the two sites showed 58.5% similarity in growth trends, but these could not be attributed to a dissimilar influence of AD. The third monitoring approach evaluated the relationship between foliar and soil chemical indicators. Across FIA plots, nutrient concentrations varied by tree species. The first year results from a

potted-seedling study suggest that soil acidity influences growth, and foliar concentrations are related to growth rates.

This evaluation of the effects of AD on the MNF can be used to develop adaptive management plans and a monitoring program that will meet the AD-related objectives of the 2006 Forest Management plan."

Anthony Creek Watershed

Monitoring for Item 32. This was the second season for sampling soils in the Anthony Creek Watershed. In summer 2008, the YCC crew dug two pits on Rucker Gap ridge to continue to obtain data points in sensitive geologies with little soil characterization data. These two pits were excavated and sampled by horizon. Samples were sent to the University of Maine for general forest soil chemistry analysis and to the Soil Testing Lab at Pennsylvania University for the specific Aluminum Stress Test (Ca:Al ratio using a $SrCl_2$ extraction method). This location was sampled as part of a continuing effort to capture baseline data not only for the Forest-wide assessment of soil chemical properties but also because this area is planned as a prescribed burn as part of the White Sulphur Prescribe Burn Project, Marlinton Ranger District. A background description of the watershed was given in the 2007 Soil Resource Monitoring section.

Preliminary results from these two pits show that the soils are not as sensitive to acidification from atmospheric deposition as predicted. There are moderate levels of Ca in the soil profile and CEC and BS levels are higher than those found in other watersheds that were rated sensitive with regard to adverse risk for base cation leaching due to acidic atmospheric inputs, such as Cherry River or Lower Williams River.

Evaluation, Conclusions, and Recommendations. The 2008 Anthony Creek Watershed Assessment was originally going to be the vehicle used to discuss sampling results and provide general guidance for land management activities related to Monitoring Item 32. However, due to budget and personnel constraints, the assessment may be postponed or canceled. If this assessment does not occur, the results of this soil sampling in conjunction with the results from 2007 should be used in whatever site-specific projects that are developed for this area.

Lower Williams River Terrestrial Liming Project

Monitoring for Item 32. The second area sampled was related to pre-monitoring work for the Lower Williams Terrestrial Liming Environment Assessment currently underway in 2008. This project is looking at soil chemistry levels in the watershed to evaluate the need for base cation restoration, particularly calcium. Samples were taken in units to be harvested in the upcoming Lower Williams Vegetation EIS project, and in areas adjacent to the units for additional restoration opportunities and as background or control areas. Five small pits were hand dug either in a linear transect 50 feet apart across the landscape or in a cardinal star pattern, depending on the shape of the unit selected. The O horizon, A horizon, and top of the B or transitional horizon were sampled, and samples were sent to the above mentioned labs for testing.

In conjunction with the soil sampling, foliar sampling was done at five of the sites. Twenty samples per site were taken. Two to three trees species were sampled, depending on the species available at each site. Sun side, top canopy leaves were shot from the uppermost branches and collected as they fell to the forest floor. These leaves were labeled, bagged, air-dried, and sent to the University of Maine Soil Testing Lab for foliar chemical analysis.

Evaluation, Conclusions, and Recommendations. Results of the 2008 sampling efforts are expected in the first quarter of FY 2009. Evaluation will occur as part of the Lower Williams Terrestrial Liming Project. West Virginia University is now involved and has assigned a doctorial student to conduct basic analyses and statistics on the incoming and existing data set. Results will be intreptated as part of this student's doctorial dissertation.

ITEM 31. Is soil detrimental disturbance associated with land management activities below the 15% soil productivity loss threshold?

This monitoring item was not addressed as in years (2004-2007) past by analyzing soil disturbance in a defined unit and calculating % disturbance based on area disturbed and size of unit. Instead, the Forest participated in the development and implementation of new Soil Quality Management Standards that are based on Detrimental Soil Disturbance Monitoring Protocols. After several legal challenges to the 15% soil productivity loss threshold standard and how it is implemented on Forests out West, the Forest Service worked with the Pacific Northwest Research Station to develop a new approach that looks rather at soil quality indicators and detrimental soil disturbance in management units pre- and post-activity. This effort put into action a chain of events that let to the rewriting of Section 2550 of the Forest Service Handbook (FSH). This direction became final in late 2008 and is currently being adopted by all Forests across the U.S. Training sessions on how to implement the new direction started in the summer of 2008, and protocols tested on several units on the MNF.

The new direction is based on a statistical sampling methodology and allows for professional judgment by a Soil Scientist to make a call as to whether disturbance in a management unit is deemed detrimental and whether that disturbance is significantly detrimental. This allows for a broad interpretation of how soil disturbance can affect a site and whether the effects are adverse, neutral, or even beneficial.

Issue: National soil management direction has not kept up with shifts in national forest and grasslands land management direction. Additionally numerous advances in technical guidance have been developed and are in place since the soil management direction was last revised.

Background: Along with advances in land management planning direction, recent court rulings (Iron Honey Restoration EIS and Lolo Post-Burn EIS) have heightened the need to refine national soil management direction. The recent *en banc* decision by the ninth Circuit Court associated with the Lands Council v. McNair reversed the court's decision concerning on-the-ground validation, but did not reverse compliance rulings associated with Forest Service Manual (FSM) direction. The revision of the FSM 2550 has extensively engaged the Regional Soil Management Program Leaders and the Research & Development community.

In light of the revised land management planning direction the revised FSM 2550 addresses soil attribute definitions, e.g., desired soil condition, significant soil impairment, soil productivity, and soil quality that were previously not addressed. Additionally, the revised manual clearly outlines the role of decision makers. The revised manual also removes technical direction that will be addressed in the FSH 2509.

Key Points:

The revised FSM 2550 Soil Management provides:

- Clear direction to decision makers on their roles and responsibilities,
- Establishes definitions for soil attributes,
- Provides direction on the conductance of soil and terrestrial ecological unit inventory, and
- Provides direction on data storage and management.

Summary: The revision of the FSM 2550 enables land managers to have clear, concise policy and direction on sustainable soil management. The revised manual establishes definitions relevant to the soil resource to assist land management planning revision. Additionally, the revised manual provides a solid framework for regional supplemental direction

The Introduction of National Soil Disturbance Monitoring Protocols

The Forest Service considers sustainable production of natural resources and maintenance of soil and water quality high priorities as it plans and implements management activities. Legislation such as the Organic Administration Act of 1897, Multiple Use and Sustained Yield Act of 1960, National Environmental Policy Act of 1969, and National Forest Management Act of 1976 speak either directly or indirectly about providing high quality water, providing sustainable production of timber and forage, improving growth of forests and grasslands, not degrading the productive potential of the National Forests, and disclosing impacts of proposed activities on soils. Little definitive direction was given about how to accomplish these goals.

In response to these laws, all Forest Service Regions developed soil quality standards and implemented some form of direction or guidance relating to maintenance and protection of soil productivity. Over the years, a wide array of monitoring protocols and definitions of detrimental soil conditions have been developed in order to determine if, in fact, agency management practices met this direction. These uncoordinated efforts, while well-intentioned, created a number of problems and left the agency vulnerable to challenge. The most significant problem has been the inability to compare and/or share monitoring data across administrative boundaries because of: a) inconsistent or poorly designed sampling protocols, and b) inconsistent descriptions of soil disturbance categories and differing definitions of "detrimental soil conditions."

Recent court decisions have highlighted our inability to show that we are meeting agency soil quality standards. Interest groups have questioned our soil quality standards and their effectiveness in maintaining or enhancing productivity. Others have said our standards are too restrictive. The Forest Service must develop a coordinated, agency-wide adaptive management process for forest soils that incorporates defensible sampling protocols and leads to development and implementation of meaningful, supportable soil quality standards.

Development of reliable monitoring protocols for assessing and comparing soil disturbance resulting from logging operations has been identified as a key component of an adaptive management process for forest soil conservation (Curran et al. 2005). Uniform and unambiguous definitions of soil disturbance categories must be part of such protocols if accurate, consistent, and statistically sound assessments are to be made. Such categories must also relate forest productivity and hydrologic function (Curran et al. 2007).

A proposed soil quality protocol that incorporates both a statistically rigorous sampling protocol and definitions of visually observable soil disturbance categories has been developed by the USDA Forest Service Northern Region (R-1) and Rocky Mountain Research Station. It is supported by and incorporates earlier soil quality monitoring efforts in the Pacific Northwest Region (R-6). In 2008, the MNF was asked to participate in testing those protocols. The Forest Soil Scientist attended a training session in May, 2008 in R8 in Macon, GA and followed up by testing the protocol in two timber units: one that was active; and one that had been closed out.

Testing of Detrimental Soil Disturbance Protocols

II. Starting a Soil Disturbance Monitoring Project

Collect existing information on project area:

- Review current and previous aerial photos noting changes (temporally and spatially)
- Review watershed and landscape analysis for soil resource issues
- Obtain previous management activity records
- Analyze soil resource information found in forest or county soil surveys
- Identify potential risk ratings for soils
- Prioritize sampling strategy to address areas of concern

Field monitoring required identification of existing soil condition to establish the estimated soil disturbance class. Thirty protocol points were actually completed in each of two units on the MNF.

Monitoring and evaluation related to Items 31 and 41 are reported for each project below.

South Zone Marlinton Ranger District
Upper Williams – Big and Little Timber Sales

Pay Unit #4 Monitoring

Language in the Decision Notice of the Upper Williams EA stated the need to have skid road systems reviewed in specific harvest units within the Day Run South watershed of the project. The purpose of the review was to monitor concerns with soil disturbance on steeply sloping units (average slopes of 30 percent) that were adjacent to or had stream channels located in them. The soils within the harvest area are mostly the Shouns series (colluvium located on backslopes and in coves), and Cateache series (residuum forming on ridge tops and on benches.) These soils form from the Mauch Chunk geologic formation. They are rated severe for erosion hazard, and they are susceptible to mass wasting, compaction, and ponding of water. In 2007, field visits were made to the sale area to document effects discussed in the EA, and to monitor implementation effectiveness. Those findings were documented in the 2007 Soil Monitoring

Report. This unit posed an excellent opportunity since it was visited prior to harvesting and then after harvesting. The soil disturbance monitoring protocol was used to see if the concerns expressed in the EA developed or were mitigated and/or addressed during operations by the Timber Sale Administrator (TSA).

In the 2007 Monitoring Report the Soil Scientist met with the Chris Neal, purchaser, and Amy Mullins, TSA, and walked over a portion of pay unit 4 on Thursday May 3, 2007. In the summer 2008, we monitored the unit for soil quality items and tested the newly developed Soil Disturbance Monitoring Protocols. A transect spanning the unit diagonally and back down the unit at a random direction was ran. There were 30 points monitored at 100 feet apart.

Evaluation, Conclusions, and Recommendations. Soil moisture was low in the upper 30cm in the cut portion of the unit. The haul road was very dusty. Soils were dry for the most part, although some seeps on the hillside and in fresh cut skid roads were noticed. The timing of harvesting was a good selection. There was some unexpected rock damage in the ephemeral stream channels from the tracks of the harvester. A TimCo harvester was used on site to cut, trim and stack logs next to a skid system road to be transported to a landing. The monitoring showed that points in roads were detrimentally impacted, points that landed in areas where logs had been pulled or moved had been disturbed but not detrimentally. Other areas show either no impacts or minor impact. Overall, statistically (70% Confidence Interval) the site is not detrimentally disturbed. More points would be needed to make this same statement at a higher confidence interval.

North Zone – Cheat Ranger District
Yellow Bird Timber Sale – Cerulean Warbler Study

Pay Unit #1 Monitoring.
The NEPA for this timber sale was completed in 2006 as part of the Cerulean Warbler EA. The unit was harvested in a conventional manner with rubber tire skidders. Skid roads did not seem to be excavated. The geology of the site is the Chemung Formation. These relatively stable sandstones form soils that have lots of rock fragments and are loam to clay loams in the subsoil. These soils are generally well drained. A transect was conducted in accordance to the protocol and 30 points were taken in 100 foot intervals. The unit was traversed in a continuous direction from one end to the other, crossing the ridge and coves and back onto the ridge. The unit had received a shelterwood harvest.

Evaluation, Conclusions, and Recommendations. The transect data did not show that the site was detrimentally disturbed. Several sites did show some detrimental disturbance, but again those points landed in areas where equipment had been used. It was difficult to determine outside of the main skid system if the disturbance was from trees being moved within the unit or from the equipment. Regardless, that disturbance was not detrimental and the A horizons were still intact.

Summary

The Forest will need to make a change in Standards SW05 and SW06 in order to address this change in national and regional direction for soil disturbance monitoring protocols and the whether soil disturbance is detrimental. This will require an administrative correction to the Forest Plan and documentation to the Project File but will not require an amendment because the analysis would not affect the soil resource effects analysis conducted for the Forest Plan EIS. We still will ask for areas to be identified in the planning process where soil disturbance would occur and calculate how much of the area would be disturbed, but we will also now conduct statistical analysis post disturbance to determine if that type of disturbance is detrimental statistically. The 15% number will go away because the Forest Service now recogonizes that the disturbance and the effects are site specific, and the effects on site productivity are based more on that site-specific disturbance and how it is distributed across the site.

Figure SL-1. USDA Natural Resource Conservation Service, Resource Soil Scientist looks at the soil in Upper Williams Pay Unit #4 and assesses soil disturbance according to the protocol.

Figure SL-2. Upper Williams Pay Unit #4 haul road that traverses the unit. This point was determined to be detrimental soil disturbance.