U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE
FINGER LAKES NATIONAL FOREST

SOIL ASSESSMENT

June 2003

Prepared by
Tetra Tech EM Inc.
175 N. Corporate Drive
Brookfield, Wisconsin 53045

Contract No. 53-56A1-02-01628
Task Order No. 1

U.S. Forest Service Project Officers
Melissa Reichert and Nancy Burt
Green Mountain and Finger Lakes National Forests
Rutland, Vermont

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ACRONYMS AND ABBREVIATIONS

BMP	Best Management Practice
CFR	Code of Federal Regulations
DEM	Digital Elevation Model
ELT	Ecological Land Type
ELTP	Ecological Land Type Phase
FLNF	Finger Lakes National Forest
GM-FLNF	Green Mountain and Finger Lakes National Forest
GMNF	Green Mountain National Forest
FSH	Forest Service Handbook
FSM	Forest Service Manual
LTA	Land Type Association
NADP	National Atmospheric Deposition Program
NEFES	USFS Northeast Forest Experiment Station
NEPA	National Environmental Policy Act
NFMA	National Forest Management Act
NFS	National Forest System
NHFEU	National Hierarchical Framework of Ecological Units
NRCS	U.S. Department of Agriculture – Natural Resources Conservation Service
RPA	Resources Planning Act
S&Gs	Standards and Guidelines
SCS	U.S. Department of Agriculture - Soil Conservation Service
SSSA	Soil Science Society of America
SQS	Soil Quality Standard
STATSGO	State Soil Geographic Data Base
TEU	Terrestrial Ecological Unit
USDA	United States Department of Agriculture
USFS	U.S. Department of Agriculture – Forest Service

ABSTRACT

The U.S. Department of Agriculture, Forest Service has tasked Tetra Tech EM Inc. to provide an assessment of the condition of soils and the status of soil information for the Finger Lakes National Forest (FLNF). This assessment is needed for revision of the National Forest Land and Resource Management Plan (also known as the "Forest Plan").

This soil assessment provides information for the Forest Plan revision. It includes an overview of the legal and administrative framework guiding soil management on National Forest System lands, effects of major disturbances, availability of soils information, and the kinds of soils that occupy the FLNF, as well as a discussion of the major soil-related issues to be addressed in the Forest Plan revision.

This soil assessment includes the following major recommendations:

- Update standards and guidelines for soil management to incorporate the latest agency direction and scientific knowledge.
- Develop soil quality standards and incorporate them into the updated standards and guidelines.
- Develop and implement an ecological monitoring strategy.
- Work with research organizations to further identify soil parameters that influence the effects of acid deposition.
- Integrate the appropriate level of soil and ecological information into all land and resource management decisions.
- Identify and improve all areas where soil quality has been impaired.

This soil assessment further recommends that the Forest Plan revision include direction to achieve those recommendations that cannot be achieved in time to be incorporated into the Forest Plan revision.

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1.0 INTRODUCTION

The U.S. Department of Agriculture (USDA), Forest Service (USFS) has tasked Tetra Tech EM Inc. to provide an assessment of the condition of soils and the status of soil information for the soils of the Finger Lakes National Forest (FLNF) in New York. This assessment is needed for revision of the National Forest Land and Resource Management Plan (also known as the "Forest Plan").

This introduction provides an overview of the terms soil quality, health, and function and discusses the uses for this soil assessment. In addition to this introduction, the soil assessment discusses the following:

- Legal and administrative framework for managing the National Forest System (NFS) (Section 2.0)
- Soil management goals for the FLNF (Section 3.0)
- Major disturbances and the soil reference condition for the FLNF (Section 4.0)
- Soil Reference information for the FLNF (Section 5.0)
- An overview of the soils and physical setting of the FLNF (Section 6.0)
- Actions toward the soil management goals for the FLNF (Section 7.0)
- Issues and concerns that should be addressed in the Forest Plan revision (Section 8.0)
- Conclusions (Section 9.0)
- Critical additional information needs (Section 10.0)

A glossary of terms used in the soil assessment is provided in Section 11.0. References used to prepare this document are presented in Section 12.0

1.1 SOIL QUALITY, HEALTH, AND FUNCTION

Soil is a fundamental ecosystem component and a foundation of sustaining healthy forests. The objective of soil management is to maintain soil quality and health, and thereby sustain soil function and productive potential.

Soil Quality is defined as the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain or enhance water and air quality, and support human health and habitation (USDA Undated [a]).

- *Inherent soil quality* is that aspect of soil quality relating to a soil's natural composition and properties as influenced by the factors and processes of soil formation. Inherent soil quality varies among different kinds of soil.

- *Dynamic soil quality* relates to soil properties that may change as a result of soil use and management.

Soil Health is a term that can be used interchangeably with *dynamic soil quality*.

Soil Function is maintained by preserving soil health. The basic functions of soil are the following:

- Sustaining biological activity, diversity, and productivity
- Regulating and partitioning water and solute flow
- Filtering, buffering, degrading, and detoxifying potential pollutants
- Storing and cycling nutrients
- Providing physical support for terrestrial organisms, including humans, and for structures including buildings, roads and trails (USDA Undated [a]).

1.2 PURPOSE AND USE OF THIS ASSESSMENT

The assessment will be used for the following:

- Share general information with the public regarding the conditions and effects of management practices on the soil resources of the FLNF
- Assess the general health and productivity of the FLNF soils
- Identify opportunities to restore, protect, and enhance soil conditions
- Share with the public the most critical soil resource issues identified
- Identify ways to improve monitoring and evaluation of soil resource conditions
- Identify soil information gaps and needs
- Identify problems and issues that are outside the scope of forest planning

2.0 LEGAL AND ADMINISTRATIVE FRAMEWORK

The framework for managing the NFS is established in laws and regulations, and by the USFS directive system, which are summarized below.

2.1 LAWS AND REGULATIONS

The most significant federal laws and regulations that include provisions to protect soil resources on NFS lands are as follows:

- **The Organic Administration Act of 1897** established NFS reserves to improve and protect forests within the boundaries and to secure favorable conditions of water flows. By implication, this Act requires protecting and maintaining the soil resource quality.
- **The Multiple-Use Sustained Yield Act of 1960** states that management of the national forests must provide "sustained yields in perpetuity without impairment of the productivity of the land."
- **The National Environmental Policy Act of 1969 (NEPA)** requires federal agencies to assess the environmental effects of their actions. NEPA therefore requires the Forest Service to assess the impacts of planned land and resource management activities.
- **The Federal Water Pollution Control Act (also known as the "Clean Water Act" [1956, and as subsequently amended])** provides for measures to prevent, reduce, and eliminate water pollution. Because soil erosion is a source of water pollution, this Act requires management of soils to prevent or minimize erosion, including implementation of best management practices (BMP).
- **The Forest and Rangelands Renewable Resources Planning Act of 1974 (RPA)** requires an assessment of the present and potential productivity of the land. Regulations are to specify land management planning guidelines to ensure that timber will be harvested from NFS land only where soil, slope, or other watershed conditions will not be irreversibly damaged.
- **The National Forest Management Act of 1976 (NFMA)** amended the RPA. The NFMA strengthens RPA requirements pertaining to suitability and compatibility of land areas, maintenance of productivity, the need to protect and improve the quality of soil and water resources, and the need to avoid permanent impairment of productive capability of the land.
- **Title 36 Code of Federal Regulations (CFR) Part 219, NFS Land and Resource Management Planning Rules (1982) and proposed Rules (2000 and 2002)** establishes requirements for integrating all of the above mandates into National Forest Land and Resource Management Plans. Requirements to "protect and conserve soil and water resources, and not allow significant or permanent impairment of the productivity of the land" are emphasized throughout these rules, including the proposed revised rules.

2.2 U.S. FOREST SERVICE DIRECTIVES SYSTEM

The Forest Service Directives System includes the Forest Service Manual (FSM), which provides policy direction, and the Forest Service Handbook (FSH), which provides procedural direction. The FSM and FSH titles and chapters that most affect soil management are as follows:

- **FSM Title 2500** provides overall policy guidance for managing watershed and air resources throughout the NFS, consistent with all applicable laws, regulations, rules, and executive orders.
- **FSM Chapter 2550** provides overall policy guidance for managing soil resources of the national forests, consistent with all applicable laws, regulations, rules, and executive orders.
- **FSH 2509.18** provides procedural directions for a comprehensive approach to incorporating soil information into land management decisions through soil resource inventory, soil management support services, soil quality monitoring, soil interpretation, and soil information training.
- **FSH 2509.18 Chapter 2 - Region 9 Interim Directive R9 RO 2509.18-2002-1** provides regional guidelines for soil quality monitoring, establishes regional soil quality standards (SQS), and directs Forest Supervisors to "propose revised standards as needed based on ecological unit characteristics."
- **FSM Chapter 2060** provides overall policy guidance for ecological classification and mapping.
- **FSH 2090.11** provides procedural guidance for ecological classification and mapping, of which soils are a primary component.

So far as can be determined within the scope of this document, all laws, regulations, rules, and policy requirements are currently being met by the Forest Service in management of the FLNF. However, opportunities exist to enhance demonstration of compliance with requirements relating to maintaining soil quality and long-term productivity through adoption of SQSs and updating of Standards & Guidelines (S&Gs).

3.0 SOIL MANAGEMENT GOALS

One goal in the 1986 FLNF Plan directly addresses soil resources. It is stated as follows:

> "Protect the basic integrity of soil, air and water resources so they can continue their life supporting functions in perpetuity, by such requirements as preventing erosion, meeting air quality standards, preventing contamination of surface and ground water."

Several additional goals in the Forest Plan imply good soil management, because their achievement would depend in part on maintenance of soil quality. Progress toward meeting the goals in the 1986 Forest Plan is assessed in the report, "Implementing the FLNF Forest Plan - A 15 Year Retrospective (USFS 2002b).

All of the goals that address or implicate soil resources were achieved to a significant degree. However, they are generally stated as goals that merit repeated or continuing achievement year after year, rather than on a one-time basis.

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4.0 MAJOR DISTURBANCES AND REFERENCE CONDITION

Disturbances are important processes in the forest environment. The natural world is full of significant disturbances, including but not limited to fire, wind, and ice storms; downslope movement; disease; insect and fungal attack; and flooding (Klyza and Trombulak 1999). Anthropogenic (human-caused) disturbances include land clearing for crops, livestock grazing, road and trail construction, forest burning, and silvicultural practices such as timber harvest, prescribed burning, timber stand improvement, and tree planting. Other disturbances, such as acid deposition and climate change, may have both natural and anthropogenic causes. Human activities often influence the effects of some natural disturbances.

Soil conditions can both affect, and be affected by, disturbances. In the FLNF, the most significant natural disturbance is probably windfall – trees blown over and uprooted by wind. Trees in the FLNF area are susceptible to windfall because large extents of the soils have restrictive subsurface layers called fragipans that limit root penetration and water percolation.

Disturbance regimes vary over time as a result of different natural and human influences. In and around the area that is now the FLNF, variations over the past 2,000 years have been attributable primarily to human influences. Disturbances that have affected this area over three time periods are discussed in the following text, focusing on those disturbances that have affected soil quality. The reference condition to which discussion of dynamic conditions can be based is also established.

4.1 2,000 YEARS TO 300 YEARS BEFORE PRESENT

Analysis of land survey records from the 1790s indicates that forest cover occupied 97 percent of the land area of the region, and that oaks dominated the area of the present-day FLNF. Disturbance regimes included windfalls, wildlife (beaver), and fire (DeGloria 1998; Marks and others 1992). Native American settlements were in the general area, although there is no record of them being located on the uplands within the FLNF. Windfalls were dominant, resulting from limitations on soil rooting depth. The major human activity in the area was most likely hunting and limited agricultural activities (DeGloria 1998). No evidence indicates that soil quality was significantly affected by natural or anthropogenic disturbances during this period.

4.2 300 YEARS BEFORE PRESENT TO 1986

European settlement in the region began in 1798. The period of most rapid immigration of settlers to the area occurred between 1798 and 1812. Settlers cleared large tracts of land and practiced intensive agriculture. By 1850, New York led the nation in lumber production, with nearly 4,000 sawmills operating statewide. Agricultural production peaked in the area just prior to the Civil War. From the 1880s to the 1930s, over 1 million acres of farmland was abandoned in south-central New York as a result soil depletion and other economic factors. Soil depletion was caused by excessive erosion, improper nutrient management, and lack of effective conservation practices on marginal land (DeGloria 1998). By the early 1930s, soil quality in the area that is now the FLNF was severely depleted.

Between 1938 and 1941, the federal government relocated farmers to better land or jobs and purchased marginal land on over 100 farms in the area. The area under federal ownership became the Hector Land Use Area and was managed by the USDA Soil Conservation Service (SCS). The SCS stabilized soil by planting conifer trees, establishing permanent pastures, and prohibiting cultivated agriculture on the public lands. Administration of the Hector Land Use Area was transferred to the USFS in 1954 and to the Green Mountain National Forest (GMNF) in 1957. The Hector Land Use Area became the FLNF in 1985 (DeGloria 1998).

4.3 1986 TO THE PRESENT

The Forest Plan, with goals, standards, and guidelines for protection of soil and water resources, was implemented in 1986. Livestock grazing, carefully managed to protect soil quality, is practiced on about 35 to 40 percent of the land area of the FLNF. The remaining 60 to 65 percent of the FLNF is in forest and shrub openings.

Acid deposition is an anthropogenic disturbance caused by air pollution. Soil characteristics both influence the effects of and are influenced by acid deposition. In general, deep soils with a high nutrient-holding capacity and high base content can buffer acidity from acid deposition to a much larger degree than shallower, more nutrient-poor soils. In general, the soils of the FLNF are base-poor, but slightly less so in the north than the south. The soils also tend to be shallower at higher elevations and deeper at lower elevations (DeGloria 1998). This tendency suggests that FLNF soils may be more vulnerable to acid deposition at higher elevations and toward the south and somewhat more resistant at lower elevations and

toward the north. Over time, acid deposition can reduce the buffering capacity of soils. The effect of acid deposition is a subject of scientific inquiry at this time and may be a forest planning issue.

Application of Forest Plan standards and guidelines to all resource management activities ensures that soils are protected. Soil quality, with the possible exception of effects of acid deposition, is slowly being restored. It is unlikely, however, that soil quality can be restored to the pre-European settlement condition in the foreseeable future.

4.4 REFERENCE CONDITION

As discussed in Sections 4.2 and 4.3, the general condition of the soils of the area that is now the FLNF has changed significantly over the past 300 years. It is useful to cite the condition of the land at the time of arrival of the first European settlers as a reference by which to discuss the changes. Although no actual data are available regarding the condition of the soils prior to about 1790, the following may be assumed: (1) soils were for the most part undisturbed, and soil forming processes were proceeding normally; (2) No perceptible difference was identifiable between inherent and dynamic soil quality, so soils were healthy and functioning according to their inherent potential; (3) rainwater and snowmelt were readily absorbed into the soil, and released gradually to maintain stream flow, lake and groundwater levels, and support plant and animal life; and (4) soils were more fertile than today. Chemically, soils were likely less acidic and contained a higher concentration of base cations.

For purposes of this discussion, the reference condition may be defined as a bench mark, standard, or norm upon which to base discussion of dynamic conditions. The reference condition is not the same as the desired future condition. It would not be realistic to expect that soils could be returned to presettlement conditions in the foreseeable future.

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5.0 SOIL RESOURCE INFORMATION

Soil resource information for the FLNF is available in ecological mapping studies and cooperative soil surveys.

5.1 ECOLOGICAL MAPPING STUDIES

Two ecological mapping studies were conducted to identify proposed Terrestrial Ecological Units (TEUs) of the FLNF at three scales. TEUs are units of land that share features of climate, geology, topography, soils, and natural communities. They integrate knowledge of ecological processes and provide predictions of ecological potential. TEUs are defined and mapped at different scales in conformance with the National Hierarchical Framework of Ecological Units (NHFEU) (USFS 1993; Cleland and others 1997). The terrestrial component of the NHFEU is illustrated in Table 1.

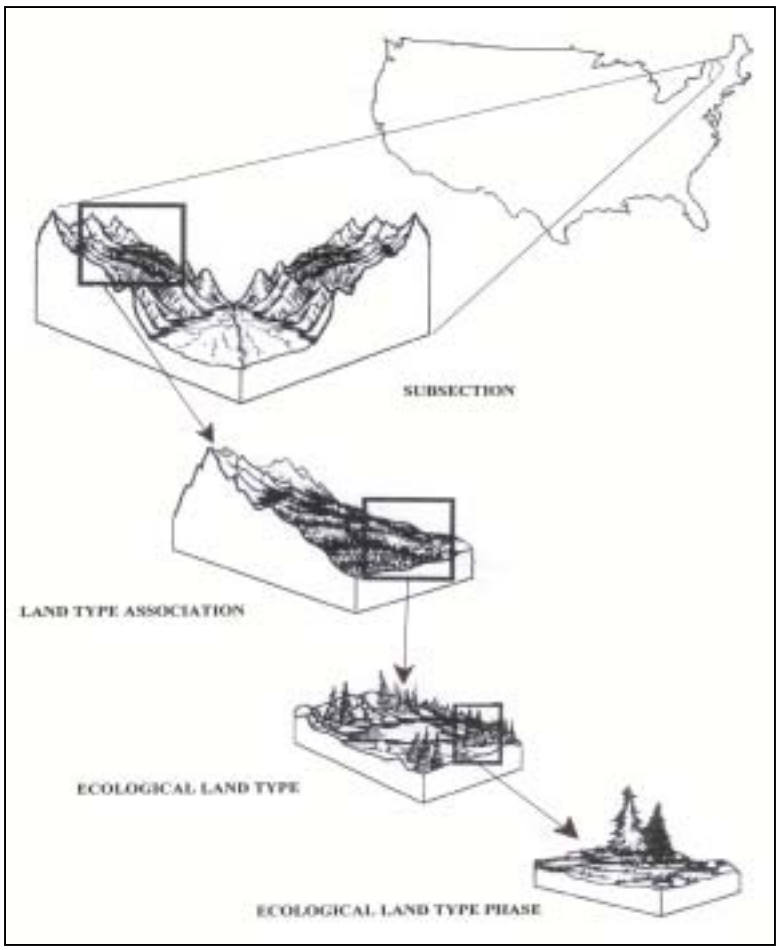
TABLE 1
NATIONAL HIERARCHICAL FRAMEWORK OF TERRESTRIAL ECOLOGICAL UNITS*

Scale or Hierarchical Level	Primary Differentiating Criteria	Purpose, Objectives, General Use	General Size Range
Ecoregion Domain Division Province	Regional climate, geology, and landform patterns	Strategic Planning and Assessment at National and International scales; Context for lower hierarchical levels	1,000,000s to 10,000s of square miles
Subregion Section Subsection	Subregional climate, geology, landform patterns, and natural community formations	Strategic state-wide, multi-agency analysis and assessment; Context for lower hierarchical levels	1,000s to 100s of square miles
Land Type Association (LTA)	Area geology, landform, and climate; soil associations, and natural community patterns	Forest or area-wide assessment and planning, watershed assessment; Context for lower hierarchical levels	1000s to 100s of acres
Ecological Land Type (ELT)	Semi-local geology, landform, and climate; soils and natural communities	Management Area planning, analysis, and monitoring; Context for ELTPs	100s of acres
Ecological Land Type Phase (ELTP)	Local landform, soils, and geology; micro-climate, and natural communities	Project planning, analysis, and monitoring	100s to less than 10 acres

*Adapted from USFS 1993.

The scales most significant to management of the FLNF are: Land Type Association (LTA), Ecological Land Type (ELT), and Ecological Land Type Phase (ELTP). These and the Subsection scale (next higher level than LTA) are illustrated schematically in Figure 1.

FIGURE 1
TERRESTRIAL ECOLOGICAL UNIT
HIERARCHICAL SCALE RELATIONSHIPS*



*Adapted from USFS 1994

5.1.1 Finger Lakes National Forest Ecological Mapping Study

The Ecological Mapping Study report (DeGloria 1998) identifies and describes proposed ELTs and ELTPs of the FLNF. ELTs are at a scale appropriate for Management Area Planning. The ELTs are subdivided into the finer-scale ELTPs that are suitable for planning individual resource management projects. The Ecological Mapping Study report also updates and refines soil information from the earlier soil survey reports and links the soil survey information to the proposed ELTs and ELTPs.

A test of the proposed ELTs found them weak in predicting vegetative composition (DeGloria 1998). Also, the proposed ELTs are not linked to the proposed LTAs within the FLNF. These deficiencies and the need to address them, are discussed further in Sections 5.1.2 and 8.1.3.

5.1.2 Finger Lakes National Forest Land Type Association Mapping Project

The Land Type Association Mapping Project report (DeGloria and others 1999) identifies, describes, and maps proposed LTAs of the FLNF. LTAs represent another hierarchical level of TEUs in the NHFEU structure. LTAs are subdivisions of subsections (USFS 1995), or aggregations (groups) of ELTs. They provide ecological information at a scale appropriate for forest-wide planning. The size of mapped LTA polygons generally ranges in the thousands of acres.

The proposed LTAs of the FLNF were developed by subdividing Subsections rather than aggregating ELTs. Consequently, there is a need for further work to link the LTAs with the ELTs.

A map of the proposed LTAs of the FLNF is presented as Figure 2. The proposed LTA names are presented in Table 2.

5.2 SOIL SURVEYS

The FLNF is included in the published soil surveys of Schuyler County (USDA 1979) and Seneca County, New York (USDA 1972). Soil association maps (also known as general soil maps) are compiled by aggregating information from the detailed soil maps included in the published soil surveys. Soil association maps and their associated data reside in the State Soil Geographic Data Base (STATSGO) (USDA Undated b). STATSGO is maintained by the Natural Resources Conservation Service (NRCS), formerly known as the SCS. A Soil Association map of the FLNF is presented as Figure 3; soil associations are defined in table 3.

FIGURE 2

FINGER LAKES NATIONAL FOREST
PROPOSED LAND TYPE ASSOCIATIONS

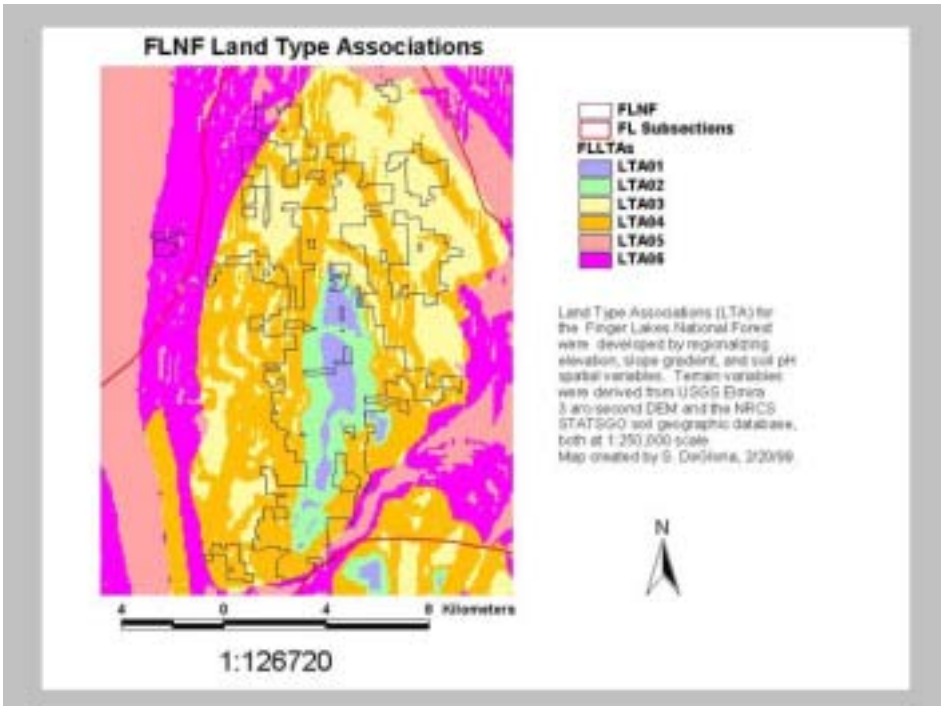


TABLE 2

FLNF PROPOSED LAND TYPE ASSOCIATION LEGEND

Symbol	Proposed Land Type Association Name
LTA01	Allegheny Uplands
LTA02	Allegheny Sideslopes
LTA03	Transitional Allegheny Lowlands
LTA04	Transitional Allegheny Moraine and Hills
LTA05	Finger Lakes Till and Lake Plain
LTA06	Finger Lakes Ravines, Cliffs, and Ledges

Source: DeGloria and others 1999

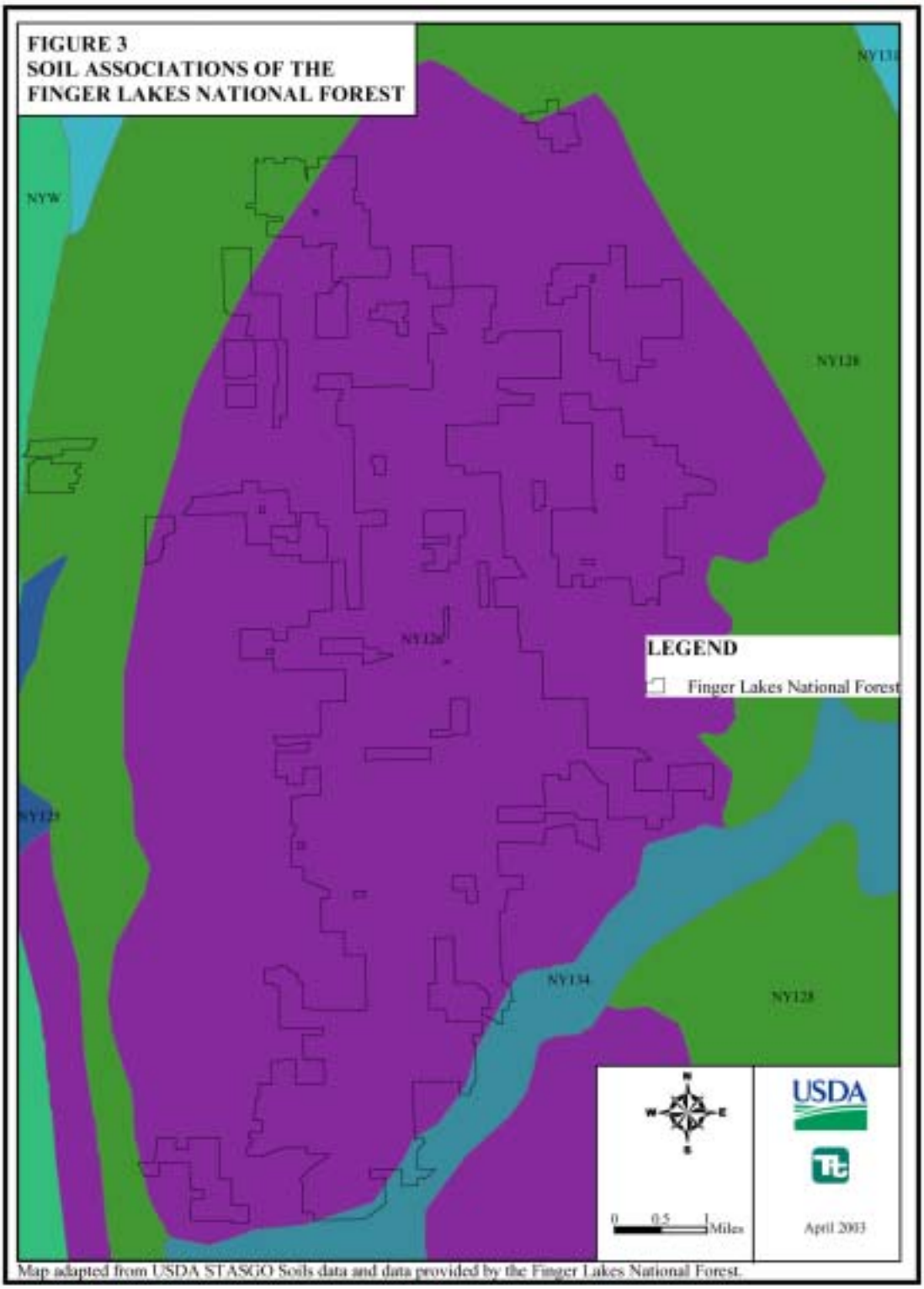


FIGURE 3
SOIL ASSOCIATIONS OF THE
FINGER LAKES NATIONAL FOREST
NYW
NY128
NY126
NY129
NY134
NY128
LEGEND
Finger Lakes National Forest
0 0.5 1 Miles
USDA
April 2003
Map adapted from USDA STASGO Soils data and data provided by the Finger Lakes National Forest.

TABLE 3

SOIL ASSOCIATION COMPONENTS

Soil Association	Principal Components (Soil Series)
NY126	Mardin, Lordstown, Langford, Arnot, Fremont
NY128	Honeoye, Lima, Lyons, Ontario, Hilton
NY 134	Chenango, Tioga, Middlebury, Palmyra, Wayland

Source: USDA 2003

5.3 USE OF SOILS INFORMATION IN FOREST PLAN REVISION

Ecological (including soil and land capability) information needed to develop the Forest Plan revision will be provided by the LTA map and associated data. LTA data can be supplemented, as needed, by ELT and ELTP data, soil surveys, and additional soils data and information included in the FLNF Ecological Mapping Study. The ELT and ELTP information in the FLNF Ecological Mapping Study can provide soils information that can help implement the revised Forest Plan. ELTs can provide information at the scale needed for Management Area planning. ELTPs provide information at the scale appropriate for planning individual resource management projects. Use of this information also can help identify further information and research needs.

6.0 SOILS OVERVIEW

This section briefly describes the physical setting of the FLNF. It provides physical context of the soils to the landscape and briefly introduces management considerations and soil classification.

6.1 SETTING

More than 98 percent of the FLNF occurs in the Cattaraugus-Finger Lakes Moraine and Hills Subsection (222Id) (DeGloria and others 1999; USFS 1995). Limited portions of the FLNF lie in the Eastern Ontario Till Plain Subsection (222Ic) to the northwest and the Central Allegheny Plateau Subsection (212Fb) to the south (USFS 1995).

6.2 PHYSIOGRAPHY AND SURFACE DEPOSITS

The FLNF is dominated by upland glacial till plains, with slopes of less than 8 percent. Sides of some of the upland ridges and hills have slopes of up to 15 percent. A few small areas, primarily bordering lowland drainageways, have slopes up to about 50 percent. The glacial till over most of the FLNF was derived from acid sandstones and shales with low lime content. The till over parts of the northern extent of the FLNF was derived partially from limestone and has a slightly higher base content. At the highest elevations of the FLNF, along the north- to south-trending Hector Backbone, soils are relatively shallow to bedrock (DeGloria 1998). Glacial outwash, alluvium, and lacustrine deposits occupy less than 1 percent of the FLNF, lying along streams and in other low-lying areas (DeGloria 1998; Degloria and others 1999).

6.3 SOIL CHARACTERISTICS AND MANAGEMENT CONSIDERATIONS

As stated in Section 4.2, the soils of the area that is now the FLNF were severely depleted by land use practices during the 1800s and early 1900s. The depletion probably included erosion of much of the topsoil, reduction of beneficial plant nutrients and nutrient storage capacity, compaction of the remaining surface layers, with corresponding reduction in infiltration capacity and increased surface runoff of precipitation. The soils are currently in a recovery period during which they have improved significantly from the original depleted condition, but full recovery is expected to take decades if not centuries.

Soils of the upland glacial till plains are dominated by a restrictive subsurface layer called a fragipan, which limits rooting depth and greatly slows the downward movement of water. It can be assumed that the fragipan is generally somewhat closer to the surface than before the soil surface layers were eroded during the 1800s and early 1900s. The upper layers of the soils are typically saturated during spring months and other wet periods. Trees growing on these soils are susceptible to being blown over by high winds.

These soils are capable of supporting moderately productive communities of Northern Hardwoods, Appalachian Hardwoods, or Appalachian Oak-Pine communities. The primary management restrictions are attributable to seasonal wetness and associated soil compaction, rutting, and puddling hazards. Susceptibility to erosion becomes a concern on steeper slopes (over about 8 percent gradient), and around heads of surface drainages. Standards and guidelines need to address these limitations.

6.4 SOIL CLASSIFICATION

The majority of FLNF soils are classified in Soil Taxonomy as Fragiaquepts and Fragiudepts. There is a relatively minor extent of Alfisols, which may be significant in terms of capacity to buffer acidity from atmospheric deposition. Along major drainageways, some alluvial soils are classified as Fluvaquents and Udifluvents. All of the soils are currently classified as having a Mesic temperature regime. However, DeGoria and others (1999) suggest that soils at the highest elevations of the FLNF, associated with LTA 01, should be recognized as having a Frigid soil temperature regime.

6.5 COMPARISON TO SOILS OF THE LARGER LANDSCAPE

In the areas surrounding the FLNF, soils similarly were developed in Wisconsin-age glacial tills, and have Mesic temperature regimes. The Eastern Ontario Till Plain Subsection to the north has a higher occurrence of Alfisols and other soils that lack fragipans. The FLNF soils appear similar taxonomically to the soils of The Central Allegheny Plateau Subsection to the south (USDA undated b).

The Federal acquisition of the present-day FLNF suggests that soil depletion was recognized as a more serious problem in the 1930s than on the surrounding lands. This leads to further speculation that the soils of the FLNF may be more fragile, and require more stringent conservation practices than those on surrounding landscapes.

7.0 ACTIONS TOWARD GOALS

The Forest Service is working in the following areas toward the goals for managing the soil resource on the FLNF:

- Application of S&Gs
- Monitoring effects of resource management activities
- Improving sites where soils are degraded (Soil Resource Improvement)

These three areas are discussed in the following subsections.

7.1 APPLICATION OF STANDARDS AND GUIDELINES

Potential impacts of each planned project are assessed and Forest Plan S&Gs are applied to minimize or eliminate the impacts. Mitigation measures are recorded in decision memoranda and notices. Projects are monitored to ensure that S&Gs are applied properly and that they are effective (USFS 2002b).

7.2 MONITORING

The USFS monitors resource management projects and activities to ensure that S&Gs are applied and effective. Projects monitored include timber sales, livestock grazing areas, and recreation trails. While evaluating the application and effectiveness of S&Gs, monitoring also identifies any further needs for protective measures and corrective actions, which are implemented as needed.

For example, during the past 3 years, the FLNF monitored the effects of grazing on soil and water resources. Monitoring included water quality and macroinvertebrate populations, and visual (photo point) monitoring of riparian area restoration. Riparian areas are being restored by fencing livestock out of strips 10 feet to 100 feet wide on each side of streams. Within the two areas fenced to date, vegetation cover and density is improving and bare soil areas are decreasing in size. This monitoring should continue for at least another 2 to 3 years.

Monitoring results are documented in FLNF annual monitoring and evaluation reports, and are summarized in other FLNF reports such as Implementing the Finger Lakes National Forest Land and Resource Management Plan a 15 Year Retrospective (USFS 2002b).

7.3 SOIL RESOURCE IMPROVEMENT

The Forest Service implements 1 to 2 projects per year on the FLNF to control erosion and improve soil quality on degraded areas. Common projects included erosion and sediment control on abandoned roads, stream bank stabilization, fencing of riparian areas to exclude livestock, and revegetation of other areas with exposed soils.

8.0 KEY ISSUES AND CONCERNS

The Forest Plan revision is an opportunity to provide new guidance to address issues and concerns. This section describes the following issues and concerns for soil resource management:

- Maintaining long term soil productivity
  - Physical impacts to soil productivity
  - Chemical impacts to soil productivity
    - Role of timber harvesting
    - Role of acid deposition
- Update Forest Plan direction for protection and enhancement of soils
- Identification and improvement of areas where soil quality is impaired
- Integration of the appropriate level of soil and ecological information into land and resource management decisions
- Emerging Issues related to soils
  - Role of terrestrial large woody debris
  - Role of carbon sequestration
  - Importance of soil floral and faunal communities
  - Protect uncommon landform/geologic/soil types
  - Preserve representative examples of ecological types

8.1 MAINTAINING LONG-TERM SOIL PRODUCTIVITY

The USFS and the public are concerned about maintaining long-term soil productivity of NFS lands. Soil productivity is defined as the inherent capacity of a soil to support the growth of specified plants, plant communities, or a sequence of plant communities (USFS 1991). Different soils vary in their inherent productivity. An objective of management is to maintain soil productivity at or near the inherent level for each particular kind of soil. Soil productivity is closely linked to soil quality. Maintaining soil quality will maintain soil productivity.

Soil impacts that can affect productivity include physical impacts such as erosion and compaction, and chemical impacts such as nutrient depletion and acidification. Erosion removes surface layers that contain the largest amount of organic matter, microorganisms, and available plant nutrients, and have the

greatest capacity for absorbing water from rainfall and snowmelt. Compaction reduces the soil's pore space, which in turn reduces capacity to absorb and store water. Reduced pore space may affect soil aeration, which is important for soil microorganisms and plant growth. Compaction can also make it physically more difficult for plant roots to grow.

8.1.1 Physical Impacts that Affect Soil Productivity

Soils are potentially exposed to erosion when the vegetative cover is removed and the surface organic layer is disturbed. Soil can be compacted by vehicular traffic or by repeated, concentrated foot traffic by animals or humans. Compaction impacts are often aggravated by high moisture conditions. Forest use and management activities that have potential to expose soils to erosion and compaction include timber sales, livestock grazing, and recreation trails. The major areas of concern with regard to timber sales are log landings, skid trails, and haul roads. S&Gs require all of these facilities to be properly located, protected from erosion, and rehabilitated when the sale is closed. S&Gs also require protection of soils along recreation trails and in concentrated livestock grazing areas.

The potential physical impacts were addressed by the soil and water S&Gs in the 1986 Forest Plan. Monitoring of management activities implementing the Forest Plan indicated that S&Gs for protection of soil and water resources "have been fairly successful," and a few changes have been suggested (USFS 2002b). Development and application of new soil quality standards and continued monitoring of the S&Gs in the revised Forest Plan will ensure that forest management activities will not result in physical impacts that reduce soil quality and productivity.

8.1.2 Chemical Impacts to Soil Productivity – Nutrient Depletion

Since the early 1970s, researchers have tried to quantify nutrient removals from eastern North American forest soils and assess the effects (Federer and others 1989). According to research, there is increasing concern that exchangeable base cation reserves in forest soils are being depleted over large parts of eastern North America due to a combination of acid deposition and tree harvesting (Watmough and Dillon 2002). The base cations most likely to be removed include calcium, magnesium, and potassium (Driscoll and others 2001; Federer and others 1989). Most studies indicate that calcium is of greatest concern because of its importance to tree growth, its capacity to buffer effects of acid precipitation, and its important role as a component of surface waters (DeHays and others 1999; Federer and others 1989; USFS 2001b). Some leaching is induced by soil disturbances caused by intensive timber harvesting

operations, but the total amount is thought to be minor compared to the total amount lost through dissolution and leaching induced by acid deposition. The chemical impacts of timber harvesting and acid deposition are further discussed below.

Harvesting: Many studies have indicated that large amounts of calcium are in wood, and therefore removed from the forest ecosystem when trees are harvested. Most studies of harvesting impacts have focused on intensive harvesting practices such as whole tree harvesting, which is not practiced nor anticipated on the FLNF. During the period 1987 to 2001, timber harvesting occurred on fewer than 27 acres annually, or about 0.166 percent of the total FLNF land. No whole tree harvesting, no clearcutting, and only 6.6 acres of total overstory were removed (USFS 2002b). The amount of nutrient loss from FLNF soils due to timber harvesting can reasonably be expected to be small due to the following:

- Low-intensity harvest operations, including no whole tree harvesting, and limited clear-cutting
- Small, selective acreage of land impacted
- Application of S&Gs to minimize losses

The Forest Service will carefully consider the adoption of additional S&Gs to further ensure that any nutrient loss from harvesting is minimized. A possible example is a requirement to leave specified quantities of large woody debris.

Acid Deposition: It is well documented that anthropogenic changes in precipitation chemistry, including acidity, have occurred over the past several decades in North America. Acid deposition is complex, but the main constituents of concern are acidic sulfates and nitrates, with smaller amounts of heavy metals such as mercury and lead. Nitrates and sulfates are essential plant nutrients; however, in excessive amounts they disrupt the nutrient balance and can increase soil acidity. Despite a downward trend in sulfate concentrations due to reductions in sulfur dioxide emissions since the 1980s, there has been no appreciable decrease in the acidity of precipitation, especially in the northeastern U.S., where cloud water pH as low as 2.1 was recorded (DeHays and others 1999). Nitrate emissions have remained fairly constant (Lovett and others 2000; Watmough and Dillon 2002), but are expected to increase throughout much of the eastern United States during the next two decades (Galloway and others 1995).

Potential consequences of acid deposition include accelerated leaching of base cations and subsequent acidification of soils (Johnson and others, 1985). Studies over the past 30 years indicate that acid deposition disrupts the calcium cycle in forests (DeHays and others 1999), and contributes to a decrease in base-cation concentrations in forest soils (Lawrence 2000). Current rates of cation depletion in the northeastern U.S. are probably the result of acid deposition (Federer and others 1989). Watershed analysis throughout the Appalachians suggests that calcium is the nutrient most likely to be depleted by acid deposition-induced leaching and intensive harvesting removals (Federer and others 1989). Calcium is essential to plant growth and is an excellent cation to buffer acidity.

Linking forest vegetation responses to soil chemical changes resulting from acid deposition has proven difficult. A 1998 study in the White Mountains of New Hampshire concluded that "forest growth in terms of aboveground tree biomass has not diminished significantly as a result of recent environmental effects." The same study cautioned that this statement did not necessarily mean that forest health was not impacted (Nuengsigkapian 1988). Fay (1995), citing 27 different research studies in the Northeast, concluded there was no firm evidence of growth decline from changes in soil nutrients. Recent research on the Allegheny Plateau points toward deficiency of magnesium and possibly calcium as a factor in sugar maple decline (USFS 2000).

A recent theory suggests that calcium may occur in forest ecosystems in larger quantities than commonly thought. This theory suggests that as trees grow they accumulate calcium in amounts greater than they can use, and store it as calcium oxalate, a crystal-like or mineral-like entity that is nearly insoluble, and therefore undetectable with normal extraction methods. In the presence of increased acidity, caused either by harvesting trees or acid deposition, calcium oxalate may become soluble and available to plants (USFS 2002a). A suggested priority research need is to better define the pools of calcium oxalate in the soil environment.

In summary, conclusive evidence that soil productivity has thus far been affected by acid deposition is lacking. However, this does not mean to imply there is no reason for concern. Central New York receives somewhat greater sulfate and nitrate deposition, and precipitation that is slightly more acid, than New England (National Atmospheric Deposition Program undated). There is potential to reduce soil quality and productivity on sensitive sites from soil nutrient cation removal induced by acid deposition. Sensitive sites are generally soils with low buffering capacity. Soils developed from acidic parent materials have inherently less buffering capacity than soils developed from basic parent materials.

Researchers' work on regional sugar maple plots suggest that glacial till soil parent materials in central New York tend to have far lower concentrations of calcium and magnesium (bases) than glacial tills in New England (USFS 2003). Within the FLNF, the upland till plains vary in lime (calcium carbonate) content predominately along a north-south transition zone with medium to low-lime tills dominating the northern part and acid tills dominating the south (DeGloria 1998). This suggests that the northern part of the FLNF may be slightly more resistant to acid deposition effects than the southern part. However, the combination of all evidence considered suggests that further monitoring and research is needed to assess the effects of acid deposition to the soils of the FLNF.

There are also secondary effects of soil acidification from acid deposition. Soil water will become more acidic when calcium is depleted. Increased soil acidity causes organic aluminum in the soil to be changed to an inorganic form that can interfere with root function and has toxic effects on aquatic life. Several studies have shown a depletion of calcium and significant increases in levels of toxic inorganic aluminum in New England surface waters (Lawrence 2000).

Another secondary effect is an increase in plant susceptibility to freezing injury and a range of other stresses from the depletion of calcium from plant cell membranes. However, this effect may be due more to the plants direct contact with acid deposition than depletion of calcium from the soil (DeHays and others 1999).

8.2 UPDATE FOREST PLAN DIRECTION FOR PROTECTION AND ENHANCEMENT OF SOILS

There is a management concern that current soil quality S&Gs do not fully reflect the latest management direction, monitoring results, and scientific knowledge (USFS 2002b). For example the 1998 FLNF Monitoring and Evaluation Report recognized that present liming frequencies were not sufficient to maintain the Forest Plan standard of pH 6.0 on many pastures. Also, current USFS direction on soil quality monitoring and SQSs (USFS 1991; 2002c) was issued after, and is therefore not included in the present Forest Plan. To address this management concern, emphasis on the following items is suggested:

- Update the S&Gs for the Forest Plan Revision to reflect recommendations from the 15-year Retrospective, and the most current scientific knowledge in the area of forest soil management.
- Develop and apply SQSs as described in Section 8.6.1, and incorporate them into the updated S&Gs

- Incorporate current research and monitoring results relating to soil quality and productivity into S&Gs and SQSs. Provide for incorporation of future research and monitoring results as they become available.

8.3 IDENTIFICATION AND IMPROVEMENT OF AREAS WHERE SOIL QUALITY IS IMPAIRED

Approximately 20 percent of the FLNF has been comprehensively inventoried for soil improvement needs. The remainder of the FLNF needs to be comprehensively inventoried, although the most severe problems are known. Future inventories should focus on road-related and grazing area erosion problems and newly acquired lands. Annual priorties are set based on severity of all known erosion/sedimentation problems and available funding. The current level of funding provides for only 1 to 2 soil improvement projects annually on the FLNF. This rate is not sufficient to address all soil improvement needs within the next 10 to 15 years. There is a management concern that the current level of soil improvement needs inventory does not provide sufficient information to effectively prioritize and fund soil improvement needs. It is suggested that the inventory of the soil improvement needs of the FLNF be accelerated, and improvement needs prioritized so that those areas with the greatest need can be corrected as early as possible.

8.4 INTEGRATION OF THE APPROPRIATE LEVEL OF SOIL AND ECOLOGICAL INFORMATION INTO LAND AND RESOURCE MANAGEMENT DECISIONS

The FLNF Ecological Mapping Study (DeGloria 1998) and the LTA Mapping Project (DeGloria and others 1999), with the three scales of proposed TEUs they identify, provide the best currently available source of land capability information. In general, LTAs support Forest Plan decisions, ELTs support Management Area decisions, and ELTPs support Project level plans. Soil surveys (USDA 1972; USDA 1979) (updated in the Ecological Mapping Study mentioned above) are available to supplement the soils information incorporated into the TEUs. It is suggested that the FLNF utilize as fully as possible the appropriate scale of TEU information in developing the Forest Plan revision, and subsequent planning management areas and projects.

8.5 EMERGING ISSUES

Several emerging issues have the potential to affect the FLNF in the near future, and should be addressed in the Forest Plan revision. These issues include the following:

- Terrestrial large woody debris
- Carbon sequestration
- Soil floral and faunal communities
- Protection of uncommon landform/geologic/soil types
- Protection of example sites of representative ecological types from anthropogenic disturbances

8.5.1 Terrestrial Large Woody Debris

Large woody debris, or downed dead wood, is important for its role in carbon and nutrient cycling, carbon sequestration, plant reproduction, wildlife habitat, and wildfire behavior (USFS 2001a). It may also be significant because of the relatively large amounts of calcium stored in wood. The following actions are suggested:

- Conduct a literature review to assemble data and information on desired amounts, types, sites, and occurrence of large woody debris
- Establish goals and objectives for large woody debris
- Consider adopting S&Gs for large woody debris in timber sale areas. The S&Gs should include guidance on what kinds, amounts, and size ranges of large woody debris should be left on what kinds of sites.

8.5.2 Carbon Sequestration

The United States' 1993 Climate Change Action Plan called on the forestry sector to sequester an additional 10 million metric tons of carbon per year by 2000 (Heath, L.S. and L.A. Joyce, 1997). Carbon sequestration is important because of the role of carbon in the formation of carbon dioxide (CO_2) and other greenhouse gases. Forestlands can store large amounts of carbon for long periods of time (Heath, L.S., J.E. Smith, and R.A. Birdsey 2002). The soil in U.S. Forests contains about 60 percent of the total forest ecosystem carbon (Heath, L.S., J.M. Kimble, and others, 2002). Forests have potential to increase carbon in soils for a long time, and may be the best available option for storing carbon in terrestrial ecosystems (Heath, L.S., J.E. Smith, and R.A. Birdsey, 2002). Range and pasture lands can also

sequester carbon, but not at the same level as forests. The FLNF may need to consider developing S&Gs for optimizing the carbon in forest and pasture soils.

8.5.3 Soil Floral and Faunal Communities

Soil is by far the most biologically diverse part of any terrestrial ecosystem. The soil is home to thousands of types of microorganisms, and to many larger species, such as worms, ants, burrowing rodents, and plants. The exceedingly diverse soil biota is extremely important to nutrient cycling and other important ecosystem functions. The importance of managing soil floral and faunal communities may become an important issue.

8.5.4 Protection of Uncommon Landform/Geologic/Soil Types

It may be important to preserve examples of uncommon types of landforms, geologic types, and/or soil types that exist in the FLNF, for scientific, research, or monitoring purposes. Some examples might be steep ravines and their associated soils. The need to evaluate this may become an issue or a management concern.

8.5.5 Protection of Example Sites of Representative Ecological Types from Anthropogenic Disturbances

It may be useful to exclude management activities from selected sites with important representative ecological types, such as ELTPs, in order to allow soil and other ecological processes to proceed unhindered. This could provide useful information regarding natural ecological processes, and strengthen monitoring and evaluation of changes attributable to management activities.

8.6 FUTURE MONITORING AND RESEARCH NEEDS

The FLNF conducts monitoring, but does not conduct research. The FLNF cooperates with other organizations, such as the USFS Northeast Forest Experiment Station (NEFES), universities, and others, to support research to compliment FLNF monitoring efforts.

Future monitoring and research, as suggested in the following sections, would help ensure maintenance of long-term soil productivity and address other issues and concerns discussed earlier in Section 8.

8.6.1 Develop Soil Quality Standards

FSH 2509.18 Chapter 2 - Regional Interim Directive, R9 RO 2509.18-2002-1 (USFS 2002c), provides Regional SQSs and suggests that National Forests develop more specific SQSs based on local ecological unit characteristics. SQSs provide benchmark numerical values to monitor in order to detect change. It is suggested that SQSs be developed for (1) LTAs to apply at the Forest Plan level; (2) ELTs to apply at the Management Area level; and (3) ELTPs to apply at the Project level. SQSs should become a component of the Forest Plan S&Gs. SQSs are identified in Section 10 as a critical information need.

8.6.2 Develop an Ecological Monitoring Strategy that Incorporates the S&Gs including the SQSs

An ecological monitoring strategy is a framework to guide monitoring across all resource areas in a coordinated manner. Its basic purpose is to ensure that monitoring needs are identified and met. It should include all levels of monitoring from simple systematic observation of projects to ensure application and effectiveness of S&Gs to complex long-term monitoring projects involving research. The ecological monitoring strategy should include procedures to monitor indicators of forest health, evaluate the S&Gs on a continuing basis, identify research needs, monitor the effectiveness of soil improvement projects, and immediately correct operational problems that are found to cause soil degradation. An ecological monitoring strategy should be dynamic, subject to periodic updating, and encourage partnerships with research organizations and members of the public. An ecological monitoring strategy is identified in Section 10 as a critical information need.

8.6.3 Improve Identification of Acid Deposition-Sensitive Areas and Sites

Research in this area could possibly build on the forest sensitivity mapping project in New England and Eastern Canada. This research would help further identify and quantify acid sensitivity parameters and provide a link and verification for the till source model being developed in New England. A component of this research might include identification and quantification of soil parameters that affect buffering capacity.

8.6.4 Evaluate the Till Source Model for Applicability to the FLNF

An effort by the NEFES and White Mountain National Forest is under way in New Hampshire and Vermont to develop a till source model to provide more precise estimates of site sensitivity. The till source model is a computerized method to estimate glacier travel direction, identify the kinds and amounts of minerals transported to the selected location, and translate the information into a map useful for inferring acid sensitivity (Bailey 2000).

8.6.5 Identify Better Ways to Define and Measure Soil Productivity

This is a research challenge that includes finding more accurate ways of measuring soil nutrient content and assessing soil nutrient implications to productivity. This research need includes identifying key threshold values of major nutrients and learning more about the occurrence and significance of calcium oxalate in the soil environment. This research would attempt to determine what changes in soil chemical properties actually affect soil productivity.

8.6.6 Improve Integration of the Various Scales of TEUs

TEU identification is an iterative process. The provisional LTAs, ELTs, and ELTPs that are identified in the current study reports (DeGloria 1998; DeGloria and others 1999) represent the first iteration. The current provisional ELTs do not aggregate to nor nest within the current provisional LTAs. Additional work is needed to fully integrate the hierarchy of TEUs in accordance with the National Hierarchical Framework of Ecological Units(Cleland and others 1997; USFS 1993). Additional analytical work is also needed to improve the predictive value of the ELTs and ELTPs with regard to vegetative communities (DeGloria 1998).

9.0 CONCLUSIONS

This section briefly summarizes the overall soil conditions and the FLNF's capability to address key issues and concerns.

9.1 OVERALL EXISTING SOIL CONDITIONS

The general health of the soils of the FLNF today is good; the only exceptions are a few localized eroding areas along roads and trails, and a few small eroded and/or compacted riparian areas. Use and management activities, such as timber sales and various types of recreational trails, have some potential to adversely affect soils, but these activities occur only on a small portion of the FLNF. Livestock grazing occurs over a larger proportion of the land area, about 28 percent, or 4,500 acres (USFS 1986). Soil impacts from all of these activities are mitigated by careful application of S&Gs.

The general health and condition of soils surrounding the FLNF cannot be expected to be as high as for soils on the FLNF. The primary reasons for lower soil health in the surrounding area are that land uses are more intensive, human population is more dense, and there are multiple landowners with many different management scenarios. Land surrounding the FLNF is typically used for agriculture, including crop production and livestock grazing.

9.2 CAPABILITY TO ADDRESS KEY ISSUES AND CONCERNS

The capability of the USFS to address the key issues and concerns discussed in Section 8 is assessed in the following sections. The rate at which the recommendations are achieved will be highly dependent on future funding levels.

9.2.1 Maintain Long-Term Soil Productivity

Maintaining long-term soil productivity, discussed in Section 8.1, is the dominant issue. The other issues identified are actually parts of this overall issue. The FLNF's capability to address this dominant issue is dependent on its capability to address the other, related issues.

9.2.2 Update Forest Plan Direction for Protection and Enhancement of Soils

This management concern is discussed in Section 8.2. It includes developing SQSs, updating the S&Gs, incorporating the SQSs into the updated S&Gs, and applying current and future research and monitoring results relating to soil quality and productivity.

Develop SQSs: This is also discussed in Section 8.5.1 as a future monitoring and research need. The Regional SQSs (USFS 2002c) provide an umbrella under which FLNF SQSs can be developed. It is suggested that Green Mountain (GM)-FLNF staff develop LTA-specific SQSs for the Forest Plan revision. This can lead to ELT-specific and finally ELTP-specific, SQSs to be applied to projects. Initially, the SQSs should be based on what is currently known about the capabilities of the soils and ecological units that occur on the FLNF. The FLNF is capable of developing initial SQSs for the Forest Plan revision, and updating them periodically as knowledge is gained through experience, monitoring, and research.

Update S&Gs: The FLNF has already identified needs and opportunities to update S&Gs for soil enhancement and protection, as discussed in the 15-year Retrospective (USFS 2002b). The FLNF is capable of updating the S&Gs, and incorporating SQSs.

Applying current and future monitoring results: The FLNF can incorporate current research and monitoring results into SQSs and S&Gs. The FLNF can also provide direction to incorporate future research and monitoring results into the Forest Plan revision.

9.2.3 Identify and improve Areas Where Soil Quality has been Impaired

This management concern is discussed in Section 8.3. Currently, available funding allows accomplishment of only 1 to 2 soil improvement projects per year. This rate is not sufficient to improve all areas within 10 to 15 years. The FLNF should be capable of completing a soil improvement needs inventory within 5 years, and then keeping it updated. A completed inventory and prioritized documentation of needs may provide a basis to increase funding and capability to accomplish the need improvements within a shorter time period.

9.2.4 Integration of the Appropriate Level of Soil and Ecological Information Into Land and Resource Management Decisions

This issue and concern is discussed in Section 8.5. Soil Surveys and proposed LTAs, ELTs, and ELTPs covering the entire FLNF are readily available. The FLNF is capable of utilizing them to incorporate the appropriate scale of soil and ecological information into their land and resource management decisions.

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10.0 CRITICAL ADDITIONAL INFORMATION NEEDS

S&Gs need to be revised to reflect current management direction and scientific knowledge regarding soil management, including riparian areas. The Forest Plan revision should include the revised S&Gs, and direction to address the following critical needs within the next five years:

- SQSs are needed to provide a basis to monitor changes in soil properties for the LTAs, ELTs, and ELTPs that are mapped on the FLNF.
- More definitive information is needed on the chemical aspects of soil productivity, including calcium dynamics, buffering capacity, and effects of acid deposition. This will be an ongoing effort, and should present opportunities to involve research partners. Significant progress should be achieved within 5 years.
- Finally, an ecological monitoring strategy is needed that incorporates SQSs, and is flexible enough to incorporate new information as it becomes available. A successful monitoring strategy should:
  - Ensure implementation of S&Gs, including SQSs
  - Ensure effectiveness of S&Gs, including SQSs
  - Assess validity and accuracy of ecological unit mapping
  - Include provisions for cooperative monitoring efforts to assess long-term effects of broad-scale phenomena, such as acid deposition

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11.0 GLOSSARY

This section presents definitions of terms used in the text, and also of some terms imbedded in the glossary that might not be readily understood by the reader. References used to prepare these definitions are included in Section 12.

Alfisols. Soils with a subsurface layer of clay accumulation and medium to high base supply. One of ten soil orders in the U.S. system of soil taxonomy (Buol and others 1973).

Alluvial. Pertaining to processes or materials associated with transportation or deposition by running water (Soil Science Society of America [SSSA] 1997).

Alluvium. Sediments deposited by running water of streams and rivers. It may occur on terraces well above present streams, on the present flood plains or deltas, or as a fan at the base of a slope (SSSA 1997).

Aquents. Entisols that are saturated with water for periods long enough to limit their use for most crops other than pasture unless they are artificially drained. (A suborder in the U.S. system of soil taxonomy) (SSSA 1997).

Aquepts. Inceptisols that are saturated with water for periods long enough to limit their use for most crops other than pasture or woodland unless they are artificially drained. (A suborder in the U.S. system of soil taxonomy) (SSSA 1997).

Base cations. Positively charged ions of base elements. Basic nutrient elements in soils, especially, but not exclusively calcium and magnesium.

BMPs. Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters (40 CFR 130).

Clastic. Noting or pertaining to rock or rocks composed of fragments or particles of older rocks or previously existing solid matter; fragmental (Random House 1966).

Dystrudepts. Acid Udepts (USDA 1999).

Ecological Land Type (ELT). A specific scale of TEU. A subdivision of a LTA or an aggregation of ELTPs. Individual ELTs are generally hundreds of acres in size.

Ecological Land Type Phase (ELTP). A specific scale of TEU. A subdivision of an ELT. Individual ELTPs range in size from less than 10 to a few hundred acres.

Entisols**.** Mineral soils that have no distinct subsurface diagnostic horizons within 1 meter of the soil surface (an order in the U.S. system of soil taxonomy) (SSSA 1997).

Fluvaquents. Aquents with stratified layers, developed in recent alluvium.

Fluvial. (1) Pertaining to streams, (2) growing or living in streams or ponds, or (3) produced by river action, as a fluvial plain (U.S.Geological Survey 1978).

Fluventic Dystrudepts. Dystrudepts on flood plains developed in recent alluvium (USDA 1999).

Fragiaquepts. Aquepts that have a fragipan.

Fragiudepts. Udepts that have a fragipan.

Fragipan. A natural subsurface horizon with very low organic matter, high bulk density and/or high mechanical strength relative to overlying and underlying horizons; has hard or very hard consistence (seemingly cemented) when dry, but showing a moderate to weak brittleness when moist. The layer typically is slowly or very slowly permeable to water, is considered to be root restricting, and usually has few to many bleached, roughly vertical planes which are faces of coarse or very coarse polyhedrons or prisms (SSSA 1997).

Frigid. A soil temperature regime that has mean annual soil temperatures of >0° C but <8° C, >5° C difference between mean summer and mean winter soil temperatures at 50 cm below the surface, and warm summer temperatures (SSSA 1997).

Glacial Till. (See Till) (SSSA 1997).

Hapludalfs. Udalfs with a relatively thin subsurface layer of clay accumulation.

Inceptisols. Mineral soils that have one or more pedogenic horizons (natural layers) in which mineral materials other than carbonates or amorphous silica have been altered or removed but not accumulated to a significant degree. Water is available to plants more than half of the year or more than 90 consecutive days during a warm season (an order in the U.S. system of soil taxonomy) (SSSA 1997).

Lacustrine deposit. Clastic sediments and chemical precipitates deposited in lakes (SSSA 1997).

Land Type Association (LTA) (also Landtype Association). A specific scale of TEU. A subdivision of a Subsection or an aggregation of ELTs. Individual LTAs generally range in size from hundreds to thousands of acres.

Mesic. A soil temperature regime that has mean annual soil temperatures of 8° C or more but less than 15° C, and more than 5° C difference between mean summer and mean winter soil temperatures at 50 cm below the surface (SSSA 1997).

Moderately well drained. A natural soil drainage class in which water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory though permanent. The soils are wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a moderately low or lower saturated hydraulic conductivity in a layer within the upper 1 meter (USDA 1993).

Outwash. Stratified detritus (chiefly sand and gravel) removed or "washed out" from a glacier by melt-water streams and deposited in front of or beyond the end moraine or the margin of an active glacier. The coarser material is deposited nearer to the ice (SSSA 1997).

Psamments. Entisols that have textures of loamy fine sand or coarser in all parts, have <35% coarse fragments, and that are not saturated with water for periods long enough to limit their use for most crops (a suborder in the U.S. system of soil taxonomy) (SSSA).

Soil Taxonomy: U.S. Department of Agriculture soil classification system (SSSA 1997).

Subsection. A specific scale of TEU within the NHFEU. A subdivision of a Section or an aggregation of LTAs. An individual subsection generally ranges in size from hundreds to thousands of square miles.

Terrestrial Ecological Unit (TEU). A mapped unit of land with relatively uniform properties or patterns of soils, geology, landforms, climate, and potential natural vegetation, with relatively uniform productive capacity and response to management actions. TEUs are defined at different scales in conformance with the NHFEU.

Terrestrial Ecological Unit Inventory (TEUI). A map of TEUs with descriptive and interpretive information.

Till. Unsorted and unstratified earth material, deposited by glacial ice, which consists of a mixture of clay, silt, sand, gravel, stones, and boulders in any proportion (SSSA 1997).

Udalfs. Alfisols that have a udic soil moisture regime and mesic or warmer soil temperature regimes. Udalfs generally have brownish colors throughout, and are not saturated with water for periods long enough to limit their use for most crops (a suborder in the U.S. system of soil taxonomy) (SSSA 1997).

Udic. A soil moisture regime that is neither dry for as long as 90 cumulative days nor for as long as 60 consecutive days in the 90 days following the summer solstice at periods when the soil temperature at 50 cm below the surface is above 5°C (SSSA 1997).

Udepts. Inceptisols that have a udic moisture regime (USDA 1999).

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12.0 REFERENCES

Bailey, S.W. 2000. "Incorporating Geochemistry in the Management of Northern Forests – A Pilot Program on the White Mountain National Forest.", *Acid Deposition Conference*. New Hampshire Technical Institute. June 27.

Buol, S.W., Hole, F.D., and McCracken, R.J. 1973. Soil Genesis and Classification. The Iowa State University Press.

Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. "National Hierarchical Framework of Ecological Units." In, Boyce, M.S., and A. Haney, eds., *Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources*. Yale University Press. pp. 181-200.

Code of Federal Regulations Chapter 40 Section 130.

DeHays, D.H., P.G. Schaberg, G.J.Hawley, and G.R. Strimbeck. 1999 "Acid Rain Impacts on Calcium Nutrition and Forest Health". BioScience. Vol. 49 No.(10). pp. 789-800.

DeGloria, S.D. 1998. Finger Lakes National Forest Ecological Mapping Study, Final Report. U.S. Forest Service, Green Mountain National Forest. Institute for Resource Information Systems, Center for the Environment, Cornell University. September.

DeGloria, S.D., D.H. Burbank, and E.D. Falconer. 1999. Finger Lakes National Forest Land Type Association Mapping Project. Cornell Institute for Resource Information Systems. U.S. Forest Service, Green Mountain National Forest. 30 September.

Driscoll, C.T., G.B. Lawrence, A.J. Bulger, T.J. Butler, C.S. Cronan, C. Eagar, K.F. Lambert, G.E. Likens, J.L. Stoddard, and K.C. Weathers. 2001. "Acidic Deposition in the Northeastern United States: Sources and Inputs, Ecosystem Effects, and Management Strategies." *BioScience*. Vol. 51 No. 3: 180-198. March.

Fay, S. 1995. "Soil Nutrient Depletion." Internal staff paper. U.S. Forest Service, White Mountain National Forest.

Federer, G.A., J.W. Hornbeck, L.M. Tritton, C.W. Martin, and R.S. Pierce. 1989. "Long-Term Depletion of Calcium and Other Nutrients in Eastern U.S. Forests." Environmental Management. Vol. 13, No. 5. pp. 593-601.

Galloway, J.N., W.H. Schlesinger, H. Levy II, A. Michaels, and J.L. Schnoor. 1995. "Nitrogen Fixation: Anthropogenic Enhancement-Environmental Response." *Global Biogeochemical Cycles*. Vol. 9:235-252.

Heath, L.S. and L.A. Joyce. 1997. "Carbon Sequestration in Forests as a National Policy Issue. Communicating the roles of silviculture in managing the national forests: *Proceedings of the National Silviculture Workshop.* May 12-21, Warren, PA. Northeastern Forest Experiment Station. General Technical Report NE-NE-238. pp. 29-36.

Heath, L.S., J.M. Kimble, R.A. Birdsey, and R. Lai. 2002. "The Potential of U.S. Forest Soils to Sequester Carbon." *The Potential of U.S. Forest Soils to Sequester Carbon and Mitigate the Greenhouse Effect*. CRC Press. Chapter 23, pp. 385-394. On-line Address: http://www.fs.fed.us/ne/durham/4104/abstract/HeathKimbleB2002.htm

Heath, L.S., J.E. Smith, and R.A. Birdsey. 2002. *Carbon Trends in the U.S. Forestlands: A Context for the Role of Soils in Forest Carbon Sequestration.* The Potential of U.S. Forest Soils to Sequester Carbon and Mitigate the Greenhouse Effect. CRC Press. Chapter 3. pp. 35-45. On-line Address: http://www.fs.fed.us/ne/durham/4104/abstract/HeathSmithB2002.htm

Johnson, D.W., D.D. Richter, G.M. Lovett, and S.E. Lindberg. 1985. "The Effects of Atmospheric Deposition on Potassium, Calcium, and Magnesium Cycling in Two Deciduous Forests. Canadian Journal of Forest Research. Vol. 15:773-782.

Klyza, Christopher McGrory, and Trombulak, Stephen C. 1999. "The Story of Vermont A Natural and Cultural History." Middlebury College Press.

Lawrence, G. 2000. "Effects of Acidic Deposition on Soils.". *Acid Deposition Conference*. New Hampshire Technical Institute. June 27.

Lovett, G.M., K.C. Weathers, and W.V. Sobczak. 2000. "Nitrogen Saturation and Retention in Forested Watersheds of the Catskill Mountains, New York." *Ecological Applications.* Vol. 10 (1) 73-84. Ecological Society of America.

Marks, P.L., S. Gardescu, and F.K. Seischab. 1992. Late Eithteenth Century Vegetation of Central and Western New York State on the Basis of Original Land Survey Records. New York State Museum Bulletin No. 484. The University of the State of New York, Education Department, New York State Museum, Biological Survey.

National Atmospheric Deposition Program (NADP). Undated. On-Line Address: http://nadp.sws.uiuc.edu/

Nuengsigkapian, P. 1998. "Have our Forests Stopped Growing? Detecting Changes in Forest Productivity Through Analyzing 150 years of Aboveground Biomass Accumulation in the White Mountains of New Hampshire." Center for Environmental Studies, Brown University.

Random House. 1966. The American College Dictionary. Barnhart, C.L., Ed. in Chief.

Soil Science Society of America. 1997. Glossary of Soil Science Terms. February. On-line Address: http://www.soils.org/sssagloss

U.S. Department of Agriculture (USDA). Undated (a). NRCS. Soil Quality Institute. On-line Address: <http://soils.usda.gov/sqi/sqw.html#what>

USDA. Undated (b). State General Soil Maps (STATSGO). NRCS. On-line Address: http://www.ftw.nrcs.usda.gov/stat_data.html

USDA. 1972. Soil Survey of Seneca County New York. Soil Conservation Service in Cooperation with Cornell University Agricultural Experiment Station. April.

USDA. 1979. Soil Survey of Schuyler County New York. Soil Conservation Service in Cooperation with Cornell University Agricultural Experiment Station.

USDA. 1993. Soil Survey Manual. Natural Resources Conservation Service, Soil Survey Division. USDA Handbook No. 18. On-line Address: http://soils.usda.gov/procedures/ssm/chapter 3

USDA. 1999. "Soil Taxonomy A Basic System of Soil Classification for Making and Interpreting Soil Surveys." NRCS, Soil Survey Staff. Agriculture Handbook No. 436. Second Edition.

USDA. 2003. NRCS. E-Mail Message Regarding Components of STATSGO units. From Steve Indrick, State Soil Scientist for New York. To Walt Russell, Soil Scientist, Tetra Tech EM Inc. March 4

U.S. Forest Service (USFS). 1986. Land and Resource Management Plan Finger Lakes National Forest. USDA Forest Service Eastern Region. U.S. Government Printing Office.

USFS. 1991. FSH 2509.18 – Soil Management Handbook, WO Amendment 2509.18-91-1. Chapter 2 – Soil Quality Monitoring. September.

USFS. 1993. "National Hierarchical Framework of Ecological Units." Unpublished Internal Report. ECOMAP. Revised June 1996. October.

USFS. 1994. "Ecological Subregions of the United States: Section Descriptions." Compiled by W.H. McNab and P.E. Avers. WO-WSA-5. July.

USFS. 1995. "Ecological Units of the Eastern United States – First Approximation" Map and Booklet of Map Unit Tables. Edited and integrated by J.E. Keys, Jr., W.H. McNab, and C.A. Carpenter.

USFS. 2000. "New Study Shows Multiple Factors Cause Sugar Maple Decline." News Release # 105. News Bulletin. Northeastern Research Station. January 31.

USFS. 2001a. "Down Dead Wood Statistics for Maine Timberlands, 1995." Resource Bulletin NE-150. L.S. Heath and D.C. Chojnacky. On-line Address: http://www.fs.fed.us/ne/durham/4104/abstract/HeathChojnacky2001.htm

USFS. 2001b. Soil Productivity Monitoring Report. Unpublished internal report. White Mountain National Forest. July 12.

USFS. 2002a. Internal staff memo. HBEF LTER Poster on Soil Calcium. White Mountain National Forest. Steve Fay, Forest Soil Scientist. March 28.

USFS. 2002b. "Implementing the Finger Lakes National Forest Land and Resource Management Plan A 15 Year Retrospective." USDA Forest Service, Finger Lakes National Forest. June.

USFS. 2002c. Forest Service Handbook Eastern Region (R9) FSH 2509.18-Soil Management. Chapter 2-Soil Quality Monitoring. Interim Directive No. R9RO 2509.18-2002-1. December

USFS 2003. E-Mail Message regarding Acid Deposition Effects. From Scott Bailey, Research Goecologist, Northeast Forest Esperiment Station. To Walt Russell, Soil Scientist, Tetra Tech EM Inc. March 28

U.S.Geological Survey. 1978. Chapter 7, "Physical Basin Characteristics for Hydrologic Analyses." In *National Handbood of Recommended Methods for Water-data Acquisition.* U.S. Department of Interior, Geological Survey, Office of Water Data Coordination. Reston, Virginia.

Watmough, S.A., and P.J. Dillon. 2002. Base Cation Dynamics at Forested Watersheds in Eastern North America. Trent University, ERS Program. April.