Surface Compaction Evaluation and Soil Sensitivity in Aspen Stands of the Great Lake States

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Abstract

Compaction and reduced soil porosity can be associated with loss of forest productivity. Soil compaction likewise can result in increased surface runoff and soil erosion so sites that are more susceptible to compaction could be given special consideration for management. As currently implemented, measurement of compaction on DM plots is based primarily on a visual assessment of observable surface compaction. Limitations of this approach include: (1) compaction more than a few years old may not be readily apparent to field crews, and (2) there is no quantitative measure of the degree of compaction. The objective of this study was to assess the accuracy of visual compaction assessment techniques and to identify quantitative relationships between soil physical properties sensitivity to compaction. Areas with evidence of compaction were assessed according to Forest Inventory and Analysis Phase 3 protocols on sites consisting of dominant Great Lakes soil types. These soils were stratified into regions of high and low potential risk for compaction based on soil textures within the Chippewa and Superior National Forests in Minnesota, the Chequamegon-Nicolet National Forest in Wisconsin and the Huron-Manistee and Ottawa National Forests in Michigan.

Introduction

Soil compaction from harvesting machinery frequently alters soil structure by increasing bulk density and soil strength, while decreasing porosity, infiltration capacity, and puddling (Alban, 1994; Block, 2002; McNabb 2001; Stone, 1998). Compaction can also constrain the size and extent of root systems, and limit the ability of roots to absorb nutrients, water, and oxygen (Amacher, 2004). For these reasons amount and type of soil compaction is one of the assessments made in the third phase of the Forest Inventory and Analysis (FIA) program of the USDA Forest Service. This program is responsible for conducting inventories to determine the extent and condition of the nation's forest resource and consists of three phases: Phase 1 – uses remote sensing imagery or aerial photography to classify land into forest or non-forest, Phase 2 – consists of permanently established field plots distributed across the landscape approximately one plot every 6,000 acres where field crews asses a variety of stand characteristics such as forest type, stand age, etc., Phase 3 – is designed to assess forest health by sampling a subset of Phase 2 plots where field crews asses indicators such as crown condition and soil attributes (http://fia.fs.fed.us). Soil compaction on the Phase 3 plots is determined visually as a percentage of the plot depending on three types of identifiable compaction which include: Rutted trail – Ruts must be two inches deep from the top of the mineral soil surface.

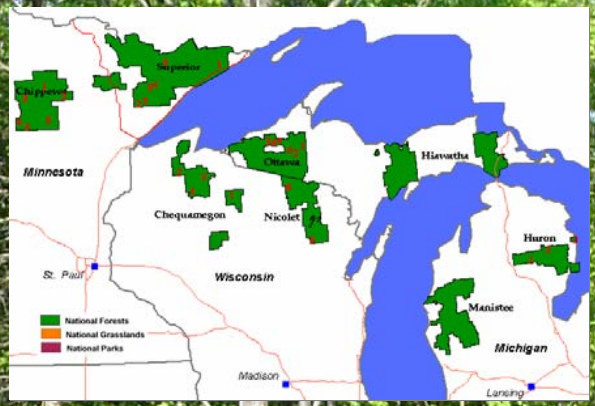
Compacted trail – Any linear feature on the landscape for travel generally distinguished by the absence of vegetation or having a somewhat sunken appearance.

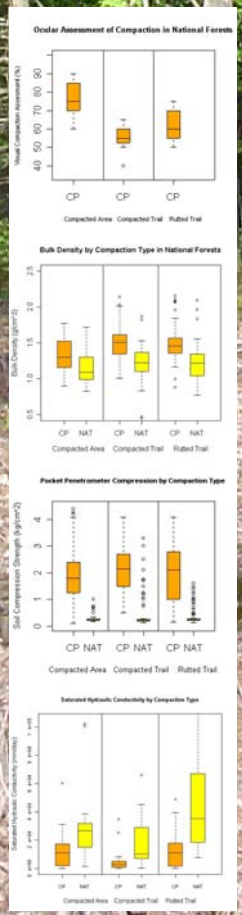
Compacted area – Of regular or irregular shape marked by the absence of vegetation or appearance of compression in comparison to nearby undisturbed areas.

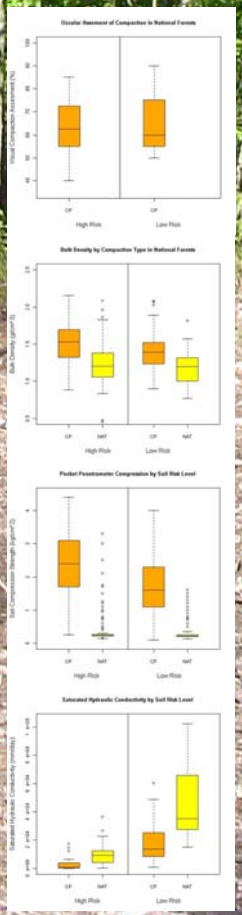
Because the effects of soil compaction on forest health vary depending upon the degree of compaction, it may be desirable to add another quantitative measure of soil compaction to the FIA program (Amacher, 2004).

Methods

Dominant Great Lakes soil types were stratified into regions of high and low potential for soil compaction based on soil texture with low-risk soils consisting of sands, loamy sands, and sandy loams and high-risk soils encompassing heavier loams, silts, and clays in recently harvested (last five years) aspen clearcuts. Within the high and low-risk soils for each of the five National Forests a total of three experimental plots were established within the clearcuts, with uncompacted natural plots located in adjacent forest stands. The experimental plot locations were chosen by identifying ten areas within each clearcut that showed evidence of at least one of the three types of compaction identified from the FIA program criteria (Compacted area, Compacted Trail, or Rutted Trail). One of these areas identified within the clearcut was then chosen randomly, and a sampling plot consisting of a circle with a 24-ft radius consistent with FIA Phase 3 plots was established. Within each plot, compaction was visually determined according to FIA Phase-3 protocols and numerous physical measurements were taken. These measurements included bulk density samples taken at 0-10 and 10-20 cm, soil compression strength samples collected using a pocket penetrometer (ELE International CL-700) with an adapter foot (CL-701) for softer soils and a Rimik CP20 Ultrasonic cone penetrometer. Saturated hydraulic conductivity was determined within the plot using a constant head permeameter (Amoozemeter). Litter depth, percent bare soil, and soil samples for carbon and nitrogen analysis were also collected at each plot. Physical measurements were collected at the end of 5 azimuths shot out from the center of each plot at random degrees and distance.







Experimental Design

At each of 5 Locations (Chippewa, Chequamegon-Nicolet, Huron-Manistee, Superior, and Ottawa National Forest):

	High-Risk Soils	Low-Risk Soils
Compacted	3 plots	3 plots
Undisturbed (natural)	3 plots	3 plots

Discussion

Preliminary analysis of the data collected during this research confirms heavier "high-risk" soils are more susceptible to compaction from harvesting activities. It also reveals that assessing soil compaction using only visually determined criteria may conceal levels of compaction apparent on research plots, therefore estimates may not relate to the degree of compaction evident. Additionally, the data from soil compression strength samples collected using a pocket penetrometer (ELE International CL-700) with an adapter foot (CL-701) for softer soils demonstrate the devices ability to determine compaction on detection monitoring plots. The device's relatively low-cost, lightweight, and small size enable it to be easily used by Phase 3 field crews (Amacher, 2004), and may be a positive addition to these crews in the future.

Ongoing related research will be done in the summer of 2005 to determine if landscape position is relevant in determining potential sensitivity to soil compaction. It will be conducted in recently harvested aspen clear-cuts in the Chippewa, and Chequamegon-Nicolet National Forests.

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