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Progress towards more uniform assessment and reporting of soil disturbance for operations, research, and sustainability protocols

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Abstract

International protocols, such as those of the Montreal Process (MP), specify desired outcomes without specifying the process and components required to attain those outcomes. We suggest that the process and its components are critical to achieve desired outcomes. We discuss recent progress in northwestern North America, on three topics that will facilitate development of and reporting in sustainability protocols: (1) common terms and comparable guidelines for soil disturbance, (2) cost-effective techniques for monitoring and assessing soil disturbance, and (3) improved methods to rate soils for risk of detrimental soil disturbance. Uniform terms for soil disturbance will facilitate reporting and exchange of information. Reliable monitoring techniques and tracking the consequences of soil disturbance for forest growth and hydrology are paramount for improving understanding and predictions of the practical consequences of forest practices. To track consequences, we urge creation of regional research and operations databases that can be used to: (1) address MP values, (2) define detrimental soil disturbances,

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(3) develop risk rating systems for operational application, and (4) improve best management practices (BMPs) and ameliorative treatments that avoid or correct detrimental disturbances.

Keywords: Soil compaction; Rutting; Monitoring; Adaptive management; Criteria and indicators; Montreal Process

1. Introduction

Sustainable management of forests requires maintenance of the soil resource including its biological, chemical and physical properties and processes. This dependency is addressed at many levels (scales): at a local and regional level through operational guidelines and standards, and more recently at national and international levels through sustainability protocols (e.g., criteria and indicators of the Montreal Process) and third-party certification.

The Montreal Process (MP) included a Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process Working Group, 1997). The MP is supported by 12 non-European countries covering 5 continents and representing 90% of the world's temperate and boreal forests. A major purpose of the Montreal Process, and the similar Pan European (formerly the Helsinki Agreement), is to provide a common framework for describing, assessing, and evaluating each member country's progress towards forest sustainability. Indicators will be used to describe, assess and evaluate progress. Two of the MP indicators for the conservation and maintenance of soil and water resources refer to area and percent of forestland with significantly diminished soil organic matter (indicator 21) or significant compaction (indicator 22) (Montréal Process Working Group, 1997). Clearly, we need to define what is "significant". Moreover, we need to validate an underlying assumption that we know what amount of organic matter loss or severity of compaction will lower forest productivity, and where and to what extent.

The MP clearly identifies indicators 21 and 22 as "b-type" indicators, which "may require the gathering of new or additional data and/or a new program of systematic sampling or basic research". Yet, some entities (national organizations/agencies), including some in the USA, are monitoring or sampling compaction before "significant" changes in compaction levels have been reliably defined or validated.

In the USA, the current response to the MP for federal forestland is to utilize the existing systematic grid of forest inventory plots as the sampling matrix, then estimate extent of compaction at these sample locations. Responsibility for responding to the MP and to the larger Forest Health issue has largely been assigned to the USFS Forest Inventory and Assessment Group (FIA). To help guide this large effort, we strongly recommend soil scientists participate in the processes and review results reported to the Montreal Process by Technical Advisory Committees (TACs) and the FIA. Of highest priority, is to quantify the practical consequences of changes in soil physical properties and soil organic matter that are important for sustainable forestry.

One approach to addressing "b-type indicators" is to use locally applicable standards as proxies and then ensure adequate validation occurs to confirm that existing guidelines and standards adequately address the intent of the indicator. This is the process adopted by the Canadian Council of Forest Ministers' in their criteria and indicators for sustainable forest management, which was developed in part to address the MP (CCFM, 2000, 2003). For soil disturbance, the various Canadian provinces are now reporting out on their level of compliance with locally applicable guidelines, which is a proxy for the related MP indicators. These guidelines address the amount of an operating area that can have specific disturbance types, such as different types of ruts, compacted trails, and displacement. Commensurate with use of guidelines and standards as proxies is the paramount need to test and adapt these guidelines and standards in a reliable continual improvement (adaptive management) framework. This is complicated by the fact that each jurisdiction has different disturbance types that are targeted by their guidelines.

No clear linkages have been established between changes in specific soil properties and productivity or sustainability, except in extreme disturbance cases. Therefore, what valid inferences or conclusions can be drawn from a national inventory of the status of soil properties in forested areas as proposed by the Montreal Process? How could inferences from such inventory data improve sustainable forestry? We suggest a more promising approach is to: (a) inventory the percentage of forested land that is controlled by other legislative or voluntary processes, such as state or provincial forestry practice codes, Sustainable Forestry Initiative (American Forest and Paper Association), Canadian Standards Association, Forest Stewardship Council, ISO 1400.1, and federal legislation (National Forest Management Act of 1976 and National Environmental Policy Act of 1969); (b) ensure that interactive regional databases are developed to facilitate information exchange and document severities of soil disturbance that are detrimental to forest productivity across the range of soils and conditions where production forestry is practiced. Existing codes, legislative acts, and voluntary agreements have documented procedures, standards, and guidelines for protecting and maintaining forest productivity. Most also seek continual improvement of processes, guidelines, and standards. Regional databases should provide the information from which detrimental soil disturbances can be defined. Best management practices (BMPs) and ameliorative treatments can subsequently be prescribed to avoid or correct disturbances that are deemed detrimental.

The Montreal Process indicates some desired outcomes (indicators) without describing the processes to achieve them. Presumably, individual countries will decide the process. We believe the adaptive management process (continuous improvement) that is used to achieve sustainability is more important than MP indicators. Further, by employing common terminology, definitions, and approaches we can reduce the burden of demonstrating sustainability.

Progress towards a common approach starts at the regional level. While most organizations have different approaches and priorities, many have similar settings and environmental issues. Therefore, it is appropriate to coordinate and cooperate on issues of sustainability. Within a region, this cooperation can result in common BMPs, tools, and databases, in which research results are tracked, summarized, and put into an operational context for successful application.

In this paper, we discuss recent regional progress in northwestern North America, on three topics that will facilitate reporting under various sustainability protocols:

A. Common terms and comparable guidelines for soil disturbance.
B. Cost-effective techniques for monitoring and assessing soil disturbance.
C. Reliable methods to rate soils for risk of detrimental soil disturbance.

2. Common terms and comparable guidelines for soil disturbance

Reliable reporting and comparing soil disturbance require agreement about terms. Unambiguous terms and definitions will increase utility of operational and research data, and improve transfer of data and experience for reports and data synthesis. Common terms are needed both for describing physical disturbance and for describing the practical application of this information. When physical properties like bulk density and porosity are reported, we need to know what is being described and how it was determined. For example, was bulk density that of the total soil or of the fine-fraction? We also need to use similar approaches to measure and describe confounding factors, such as vegetative competition. Terms like "compacted", "sensitive", "rutted", and "disturbed" need common definitions. For example, compaction is defined in various areas and applications based on visual criteria, a change in bulk density, or a change in soil macroporosity. Similarly, definitions of ruts vary tremendously in length and depth, from as short as 2 m to almost 30 m long, and from as little as 2 cm deep to over 30 cm deep. Few definitions vary with soil properties such as texture, or with climate or forest type.

2.1. Current status, and what is needed

Several classification systems exist for characterizing soil disturbance, but few have the same definitions of disturbance types or classes. These differences in definition affect guidelines and standards for controlling soil disturbance, which should be comparable, particularly at the regional level. We assert that more consistent terminology in defining soil disturbance would result in: (1) improved communication among various stakeholders of the forest resource, (2) better alignment of guidelines and standards, (3) more clearly focused research to assess the effect of soil disturbance on forest productivity and ecosystem function, and (4) more effective monitoring systems to quantify levels and effects of soil disturbance.

Ease of communication can be improved through the use of common classification systems and language. Improved communication will provide the various stakeholders (e.g., managers, loggers, and public) with the information they need to understand and decide. Common definitions of disturbance also will enable comparing and learning across ownerships and legal boundaries. Most importantly, commonality of terms may increase the awareness of the public with respect to the issue of soil conservation and its relevance to sustainability (Salafsky and Margoluis, 2003).

Desired criteria for developing consistent soil disturbance classes include: (1) disturbance types are primarily defined by visual (morphologic) attributes rather than quantitative physical properties, (2) disturbance types are easy to communicate, and (3) disturbance types are correlated with soil variables that affect tree growth and hydrological or ecological function.

Classification systems that meet these criteria have been successfully used by the B.C. Ministry of Forests (Forest Practices Code Act 1995) and Weyerhaeuser Company (Scott, 2000), and are currently under developmental use in the USFS Region 6 (Pacific Northwest). In addition to meeting the three criteria outlined above, the classification systems are successfully combined in monitoring protocols to determine severity and areal extent of soil disturbance after operational harvesting (B.C. Ministries of Forests, 2001; Heninger et al., 2002). These systems are routinely applied by non-soil scientists following a short period of training and, in some jurisdictions, after certification of persons doing these assessments.

The advantage of a visual classification system compared to a quantitative measurement (e.g., bulk density) is that monitoring is less time-consuming and easier to measure on a routine basis. However, one concern of a visual classification system is ensuring consistency and repeatability of disturbance classification among classifiers. This can be addressed through detailed survey methods and training, and periodic calibration of the visual criteria with quantitative measures such as bulk density or penetrometer resistence. This checking may be based on two-stage or double sampling schemes.

It is imperative that the disturbance classification system is validated with response variables that are ecologically relevant, such as tree growth or survival, which are direct evidence of change in the site's capacity to grow vegetation. Two examples of validation, and the need for continuous refinement, follow:

(1) Douglas-fir seedlings can tolerate saturated conditions for about 10 days before dying (Minore, 1968). Saturated areas can be created when harvesting equipment affects above- or below-ground water movement. This disturbance has been defined as class 5 (saturated usually due to severe rutting; Scott, 2000) and is considered detrimental because it results in unfavorable planting spots for Douglas-fir seedlings.
(2) Replicated field studies demonstrate that a similar class of soil disturbance can have different effects on Douglas-fir seedling growth, depending on the soil and climate zone where disturbance occurred. In the coastal Spruce zone of western Washington, no difference in 7–8 years height and volume existed between Douglas-fir planted directly into the skid-trail tracks (mostly class 2 disturbance with puddled topsoil and compacted subsoil) and trees planted off trails (Miller et al., 1996). Yet, in a drier growing season climate (near Springfield, OR) and soils with higher clay and lower organic matter content, 10-year-old trees originally planted in a similar soil disturbance class (class 2 disturbance) averaged 0.6 m (10%) shorter and less volume than trees on logged-only or tilled skid trails (Heninger et al., 2002). This indicates that the growth consequences of some disturbance types may vary with climate and soil conditions. Using a consistent method for classifying harvest-related disturbance across a gradient of soil and climate conditions is highly desirable to help track trends in occurrence and effect of disturbance on tree growth, for example.