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Drawing Lines in the Sand:
Ecosite Mapping & Soil Nutrition

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Highlights

- Ecosite classification can be an indicator of site quality as measured by soil nutrition.
- Ecosite classification can be a useful tool for determining nutritional quality of sites across different disturbance regimes.
- In boreal black spruce forests across Canada, mesic sites hold more nutrients in tree foliage than do wet sites, while wet sites contain more total nutrients in their forest floor than do mesic sites.
- Harvested boreal black spruce sites across Canada have more total nutrients--but less available nutrients--in their forest floor than do fire disturbed sites.

Forests are only as healthy and productive as the soils upon which they grow. Simply put, soil is the foundation that all vegetation is built upon. It seems obvious, then, that the strength and health of forested soils should be a primary focus of research and management. Much like the contractor constructing a new building, forest managers need to be sure that what they are building and maintaining rests upon a firm foundation.

When we talk about forest soil health, we are primarily referring to soil nutrition. Soil nutrition looks at, among other things, total and available nutrient amounts in the soil.

Forest managers need to know how much of necessary nutrients are available for tree growth in order to construct appropriate management plans. Determining nutrient amounts, however, can be time consuming and expensive. Soil sampling itself can be an arduous task, and once you have the samples, they often need to be sent out to a lab to be analyzed, increasing the cost and time associated with the sampling.

In Canada, terrestrial ecosystems are divided into a hierarchical system that, first, classifies the land into ecozones. Canada has 11 forested ecozones, each of which represents broad areas that share general characteristics (for example, the Boreal Shield, which is found from Saskatchewan to Newfoundland). These ecozones are then divided into ecoprovinces which are further defined in ecoregions (areas that contain similar biological, geological, and climatic characteristics).

While helpful in making broad generalizations about land in Canada, these coarsely designated eco-units are too broad for practical management uses. Thus, a finer eco-unit called an ecosite is typically mapped in order to classify lands in ways that are useful to managers. Ecosite mapping is done at a scale of 10-1,000 ha, and includes detailing climatic, physiography, vegetation, soil, water, fauna and land use characteristics of the site.

While ecosite mapping has the potential to be extremely useful to managers, there has been much concern over the fact that ecosites are determined (and mapped) at the provincial level. Thus, each province has its own system of classification, each highlighting different site attributes. Creating a national system whereby all Canadian ecosites are classified with a singular system has been a focus of the Canadian Forest Service over the past decade. When complete, this system has the potential to be a powerful tool in mapping ecosite types and, subsequently, aiding forest managers in sustainable forest management.

Soil Nutrition Database Project

In 2002 we began a project in which comprehensive databases, based on exhaustive literature searches, were compiled for soil nutrition in three boreal forest types (jack pine, black spruce, and mixedwood). For more information on the rationale behind and specifics of these databases, please refer to the Forest Nutrition Databases and their accompanying manual found on the SFMN website at **http://sfm-1.biology.ualberta.ca**.

In an attempt to draw broad generalizations about soil nutrition that crossed provincial ecosite classification systems, we re-classified all sites based on soil texture, moisture, and nutritional attributes. Once our classification system (national in scale, as it incorporates studies conducted in all provinces) was complete, we were interested in illustrating how it could be used effectively to draw conclusions about site types across Canada. The question we aim to answer in this note is "Can we use ecosite classification as an indicator of nutritional status of a site?" If the answer is yes, the time consuming and expensive practice of soil sampling to determine site quality could be avoided if ecosite type was known for a give site. This would provide a useful tool for forest managers wanting to determine site quality and potential productivity. We offer here some of our findings, obtained through data exploration of the black spruce database we compiled.

Statistical Significance

We cannot, at this time, attest to the statistical significance of these findings. Statistical signficance would require a much closer look at how many sample plots were included in each study within the database and would be much more detailed than the general examples we strive to offer here. We have provided standard error bars to offer some idea of how much creedance might be given to our findings. Without going into an unnecessarily lengthy statistical explanation of standard error, in simple terms, standard error refers to how much variation exists around a given estimate. Large standard error bars mean there exists a lot of variation between studies while small standard error bars indicate that there is little variation. Smaller variation allows us to be more confident in asserting generalizations as it reflects numerous studies that came up with similar measurements for a given variable.

Nutritional data trends from different angles

Angle 1: Organic vs. Mineral

We made several divisions within our database in order to look at nutrition from several points of view. The first division we made when exploring our black spruce data was between stands found on mineral soil and those found on organic soil. Because of a relative lack of data on organic sites, and because of a general lack of consistency in units of measurement between studies, this division did not yield any useful conclusions. However, we kept this division when exploring the data further because of the vast differences between organic and mineral soils. The organic sites are left out of further discussion because the dataset in total was too small to complete any useful analysis. Therefore, the following details mineral soil sites only.

Angle 2: Wet, Mesic, and Dry Sites

After the division between organic and mineral soils was made, we further divided the mineral soil data into three broad site types: wet, mesic, and dry. Due to the fact that black spruce is rarely found growing on dry sites, the data was largely lacking for the dry site (except when it came to foliar nutrient concentration). Because of this, most analysis was restricted to wet vs. mesic sites. Table 1 details which SFMN classes were included in each of these broader classifications. The SFMN Research Note *Dealing with diversity: Nutritional Site Classification* details which provincial classifications are found within each SFMN classification.

Wet Sites	Mesic Sites	Dry Sites
subhydric-medium	subhygric/submesic-medium/rich	submesic-poor
hygric/subhydric-poor	subhygric/submesic-medium/poor	submesic/subxeric-poor
subhydric/hygric-medium/poor	mesic-poor	subxeric/submesic-medium/poor
subhygric/hygric-poor	mesic-medium/poor	subxeric-xeric/medium-poor
subhygric-poor	mesic-medium	
subhygric-medium/poor	mesic/submesic-medium/poor	
hygric/mesic-medium/poor	submesic/mesic-medium	
mesic/subhygric-poor	submesic-mesic-medium/rich	
subhygric/mesic-medium/poor		

Table 1. SFMN site classifications as they fit into the broad classification of wet, mesic, and dry sites.

Some interesting nutritional trends can be seen between site types. Figure 1 shows that mesic sites contain much less Total N in the mineral soil than wet sites. Similarly, mesic sites contain less total phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) in the forest floor than do wet sites (Figure 2). At the same time, foliar nutrient concentration on mesic sites appears to be higher for N, P, and Mg than on wet sites (Figure 3).

One possible interpretation of this analysis is that mesic sites have more to lose from being harvested, particularly in regards to N and P. Mesic sites have less N reserves in the mineral soil and less P in the forest floor, while at the same time having more of these nutrients in foliar concentration than wet sites. This interpretation, however, warrants further investigation before any hard and fast conclusions are drawn, due to a number of factors which are discussed in the conclusion and recommendation section found below.

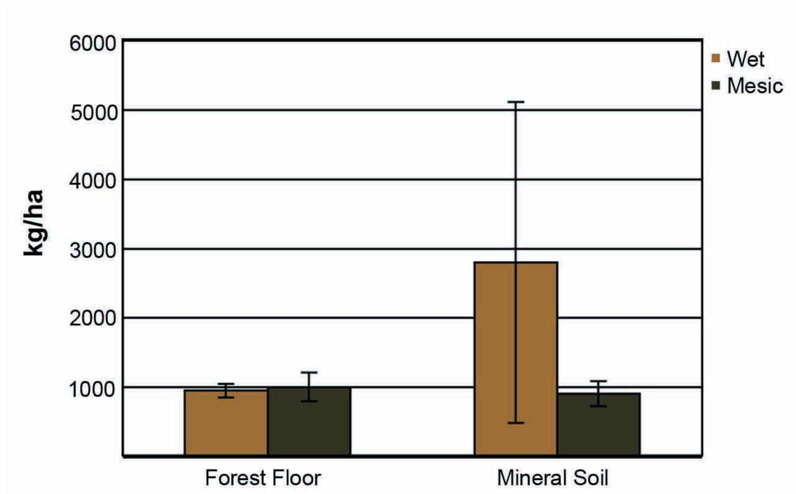


Figure 1. Total N compared in 2 generalized site types in black spruce forests.

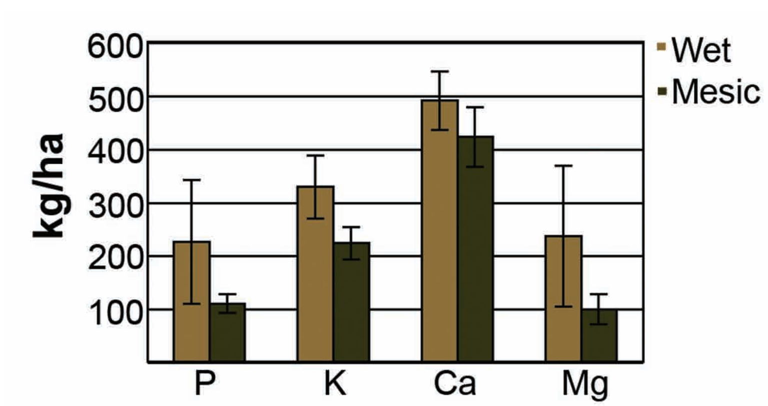


Figure 2. Total nutrient content in the forest floor of wet and mesic black spruce sites.

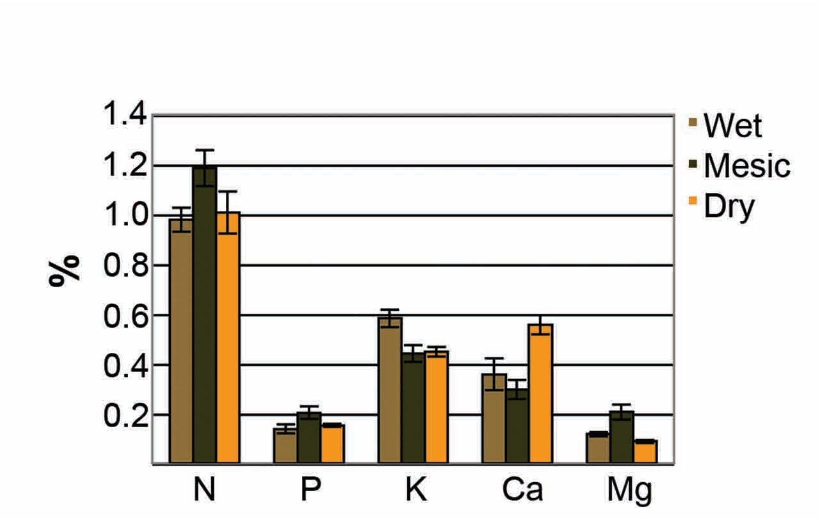
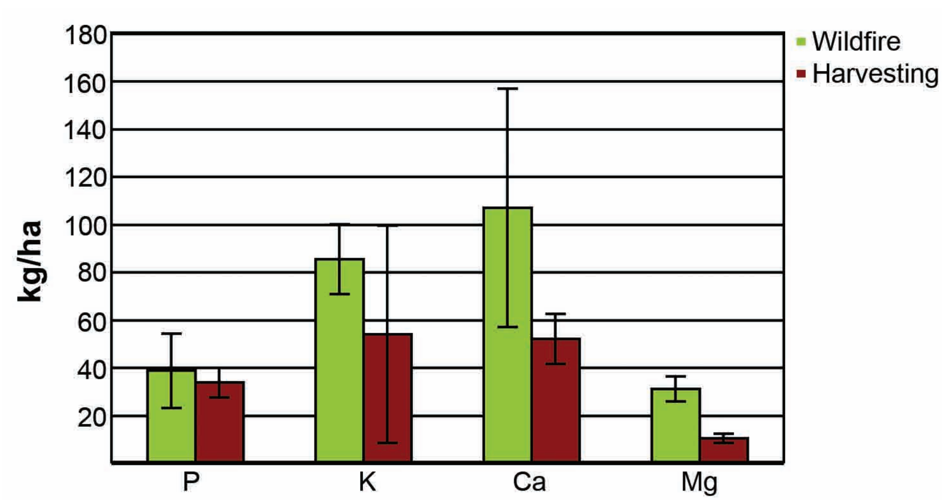


Figure 3. Foliar nutrient concentration on wet, mesic, and dry sites in black spruce forests.

Angle 3: Fire vs. Harvesting

Increasingly, the differences between boreal forests disturbed by fire and those disturbed by harvesting have been studied in order to try to bring harvested landscapes into the realm of variability found in naturally disturbed ecosystems. We were interested in illustrating how our database could be useful to those wishing to conduct such an analysis of black spruce forests across the Canadian boreal forest. Comparisons were made between sites found on mineral soils that were disturbed by wildfire and those disturbed by harvesting. As can be seen below (Figures 4-7), while harvested sites may have more total nutrients in the forest floor and mineral soil, burned sites have more nutrients available to plants. For a detailed discussion of emulation silviculture (i.e. the differences and/or similarities between harvested and burned sites), please refer to the SFMN Research Note entitled *Fire and Stand Nutrition in Canadian Boreal Forests.* For a more detailed discussion of total vs. available nutrients, please see the SFMN Research Note entitled *Nutrient budgeting in Canadian Boreal Forests.*

Figure 4. Available nutrients in the forest floor of burned and harvested black spruce sites.



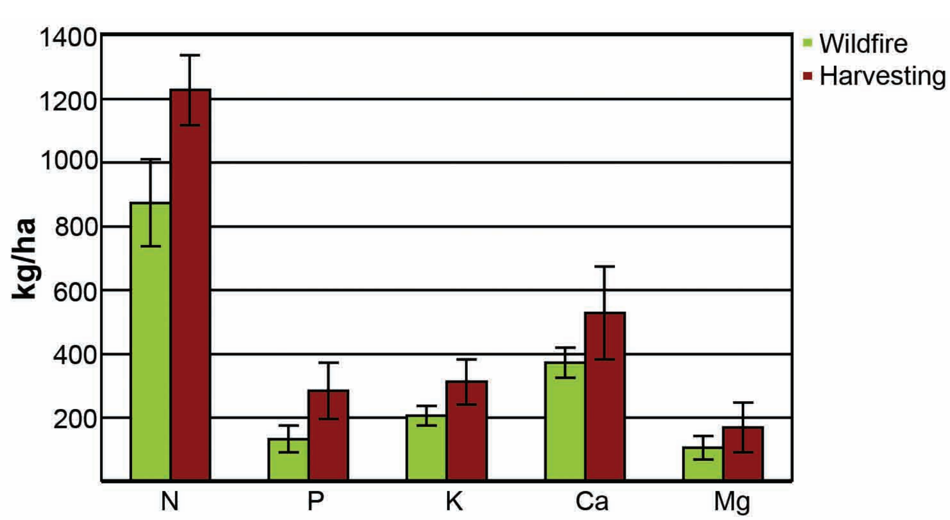


Figure 5. Total nutrients (kg/ha) in the forest floor of burned and harvested black spruce sites.

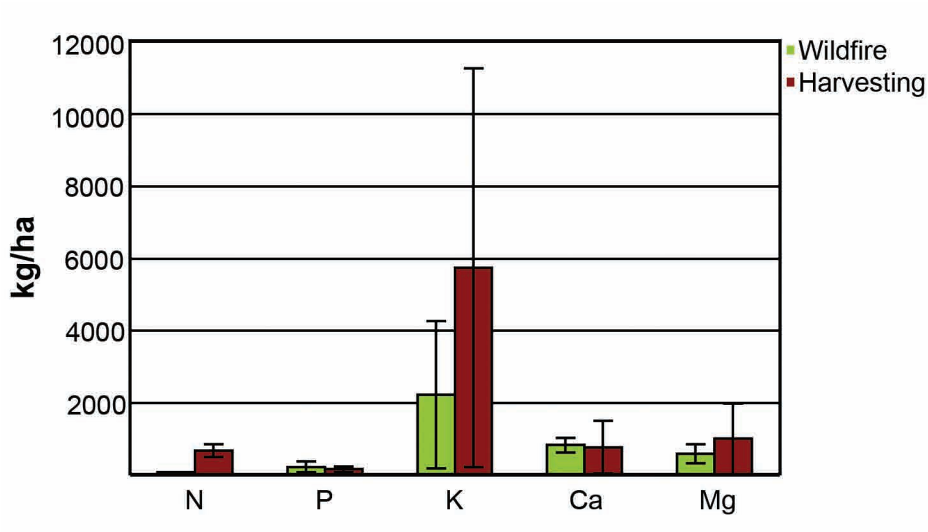
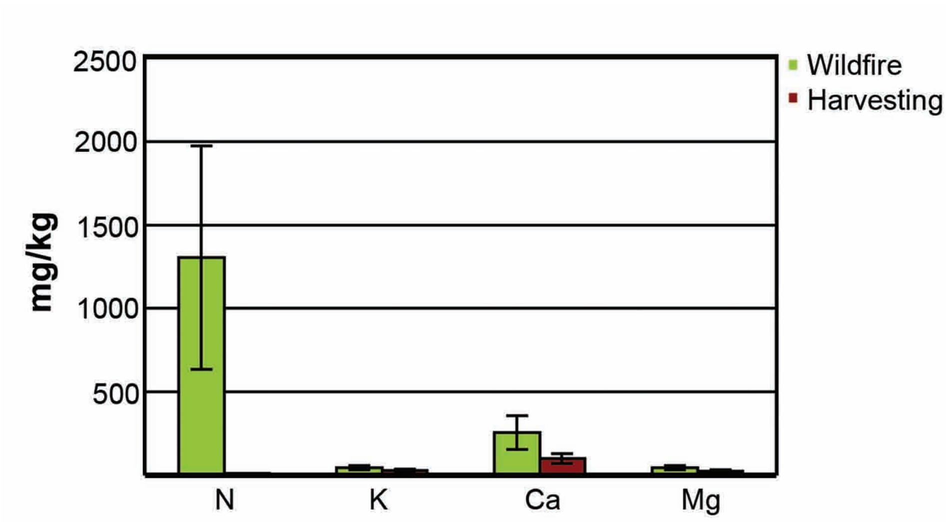


Figure 6. Total nutrients in the mineral soil on burned and harvested black spruce sites.

Figure 7. Available nutrients in the mineral soil on burned and harvested black spruce sites.



Conclusions

We began this data exploration with the goal of determining whether or not ecosite classification could be used as an indicator of stand nutrition. We explored the data further to illustrate how our databases could be used to analyze other aspects of soil nutrition within these boreal forests. While more in-depth study is warranted, our analysis here seems to suggest that ecosite classification can, infact, be an indicator of site quality as measured by soil nutrition. In addition, it is clear that the databases we have generated may serve useful purposes in determining nutritional quality across different disturbance regimes. Some generalizations that can be made from our analysis include:

- Mesic sites on mineral soils have less total nutrient content in the forest floor than wet sites do.
- Mesic sites tend to have more nutrients held in their foliage than do wet sites.
- While harvested sites have more *total* nutrients in the forest floor, they have less *available* nutrients in the forest floor than do fire disturbed sites.

Recommendations

This exercise has been extremely helpful in demonstrating that ecosite classification can be an indicator of site quality as measured by soil nutrition. In addition, our work here has identified gaps in knowledge as well as potential problems with the way we are currently collecting and/or reporting nutritional data across Canada. Based on our experience with the current data, we offer the following research directives in the hopes of shaping future research outcomes in a way that positively impacts the amount of data available for cross-country analysis of nutritional quality in Canadian boreal forests.

1) Future analysis using these databases could be extremely fruitful in identifying nutritional attributes using ecosite types as indicators. We believe that this is one direction that research could take that would provide very useful and practical information to forest managers. Additional analysis that carried statistical significance would give added weight to our demonstration here that ecosite type can, in fact, provide useful information about site quality as measured by soil nutrition.

2) A common unit of measurement should be used when reporting nutritional findings. Our data analysis would have been much more successful had we had access to all of the data within our databases. Due to the fact that some findings were given in kg/ha and some in mg/kg, with no accompanying bulk density measurement, we were unable to use much of the available data. In the very least, bulk density measurements should be given and/or future research done on generalizing bulk density measurements for general soil types and/or regions. We have a lot of good data, but its applicability on a large scale (i.e. cross-provincial classifications) is impeded by the fact that everyone reports findings differently.

3) Future research should focus on black spruce forests on organic soils. The data to date is largely lacking.

For more information on the SFMN Research Note series and other publications, visit our website at **http://sfm-1.biology.ualberta.ca** or contact the Sustainable Forest Management Network, University of Alberta, Edmonton, AB. Tel: 780-492-6659.

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