PRSSS 2010 Spring Workshop and Annual General Meeting
"Soil Resilience"

Date: March 20th, 2010
Time: 9:00 AM - 4:00 PM (Registration opens at 8:30 AM)
Location: Room 166, MacMillan Building, UBC
Sponsored in part by the Vancouver Branch of the British Columbia Institute of Agrologists, and planned in cooperation with the Northwest Forest Soils Council.

Workshop Agenda

- Registration/Poster set-up (8:30-9:00)
- Morning session: (9:00-12:00)
    - David Poon - Opening remarks (9:00-9:15)
    - Suzanne Simard -*The role of mycorrhizal networks in soil resilience with climate change* (9:15-10:00)
    - Melissa Goodman Elgar - *Soil science as a tool for archaeological research on long-term cultivation in Peru* (10:00-10:45)
  - Coffee Break (10:45-11:00)
    - Julie Deslippe – *Carbon, plant and microbial community dynamics in Low-Arctic tundra* (11:00-11:30)
    - Paul Sanborn - *Soil resilience and soil change: lessons from natural experiments on multiple time scales* (11:30-12:00)
- Lunch and AGM (12:00-1:30)
- Afternoon (1:30-4:00)
    - Chuck Bulmer- *Use of the Proctor test to evaluate compaction response and resilience of forest soils in British Columbia* (1:30-2:00)
    - Scott Holub- *Site productivity following various levels of biomass removal at Fall River LTSP: 10 year productivity* (2:00-2:30)
  - Lab tours and poster sessions (2:30-3:45)
    - Come and view the laboratory of the BelowGround Ecosystem Group in the Faculty of Forestry at UBC.
  - Closing statements and poster awards (3:45-4:00)

The role of mycorrhizal networks in soil resilience with climate change

Suzanne Simard
University of British Columbia

Resilience is "the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes " (Holling & Gunderson 2002). Complex adaptive systems, including terrestrial ecosystems, are usually considered resilient to disturbance – this is because they are comprised of many interacting parts that, through feedbacks, adaptation and emergent properties, are capable of self-regulation in response to external forcing. The resilience of soils to disturbance, or their capacity to stay within their current stability domain, depends on the strength of feedbacks among soil biological, chemical and physical properties, and interactions with climate, plants, and animals.

In forest ecosystems, mycorrhizal fungi represent a critical feedback pathway between trees and soils from which emerges properties such as nutrient uptake, forest productivity or biodiversity. Forest trees are obligate symbionts with mycorrhizal fungi; without their fungal partners, most trees cannot acquire enough soil resources to grow or reproduce; without the trees, the fungi (usually) have no source of energy. The fungal partner performs other essential services as well, such as increasing soil structure, protecting tree roots against disease or drought, and increasing the stability of soil carbon pools. When the mycorrhizal fungal network that ties plants and soils together is somehow severed, the system loses resilience and is vulnerable to collapse.

Climate change is expected to cause major shifts in tree species distributions. Some forests around the globe are already experiencing diebacks associated with summer drought or unusual winter thaws, and with this, researchers have begun to measure transformation of soil mycorrhizal communities. Death of ectomycorrhizal trees, for example, has opened space for invasion by non-mycorrhizal or arbuscular mycorrhizal plants. Even without mortality within native plant communities, plant invasions have already been observed in boreal forests, grasslands and the arctic tundra. Increased nitrogen availability, either through warming or anthropogenic nitrogen deposition, is similarly causing shifts in tree composition, productivity and microbial communities. The resilience of soils to these changes will be intimately linked to the vulnerability of tree species and their mycorrhizal symbionts to shifts in climate or disturbance patterns.

In this presentation, I will review the role of mycorrhizal fungal networks in the resilience of Douglas-fir forest ecosystems to climate change. I will show the topology of mycorrhizal networks, their role in forest recovery from disturbance, and the mechanisms by which they facilitate regeneration. Evidence for the changing importance of networks in facilitating regeneration with climatic aridity will be explored. I will discuss the role of mycorrhizal networks in stabilizing forests and soils, and thus buffering landscapes against major changes, including diebacks, invasion by exotic weeds, and soil carbon losses. Finally, I will use our knowledge of network facilitation in current forests to examine the potential role of mycorrhizal networks in facilitating or inhibiting species migrations. Considering forest ecosystems and soils as complex adaptive systems —resilient to change at some level of disturbance but shifting to new states at higher levels—provides a useful framework for understanding the critical feedback pathways, such as mycorrhizal networks, that can influence environmental change.

Soil science as a tool for archaeological research on long-term cultivation in Peru

Melissa Goodman-Elgar
Washington State University

This paper presents archaeological approaches to the resilience of human-natural systems through a case study from the Peruvian Andes. Best known for the Incas, indigenous Andean agriculture developed over several millennia and is clearly seen in major systems of stone-walled terracing. Soil stabilization is generally seen as the motivation for terrace construction. This study tested this assumption by tracking soil distribution down terraced catenas in a major agricultural valley in the Peruvian highlands. Pronounced topsoil loss was revealed through bulk and micromorphological analyses, yet cultivation continues. The resilience of these soils under long-term cultivation was found to be directly linked to soil particle aggregation and indigenous farming methods. This discussion will also explore the implications of this project for research design and future soil resilience studies.

Carbon, plant and microbial community dynamics in Low-Arctic tundra.

J.R. Deslippe[1] S.W. Simard[1], W.W. Mohn[2], and S.J Grayston[1]
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Abstract

Anthropogenic climate change threatens the stability of Arctic C stores. Soil microbes are central to the C balance of ecosystems as decomposers of soil organic matter and as determinants of plant diversity. We address the role of soil microbial communities in the response of an Arctic ecosystem to climate change. We assessed the role of mycorrhizal networks (MN) in plant-plant interactions; determined the effects of warming and fertilization on the ectomycorrhizal (ECM) community of *Betula nana*; and determined the effect of warming on soil fungi and bacteria over time. Our results indicate that MNs exist in tundra and facilitate transfer of C among *Betula nana* individuals, but not among the other plants examined. C-transfer among *Betula nana* pairs was of sufficient magnitude that it may alter plant interactions, increasing competition by *Betula nana*. We show that warming leads to a significant increase of fungi with proteolytic capacity, and a reduction of fungi with high affinities for labile N, suggesting that warming alters nutrient cycling in tundra, and may facilitate the expansion of *Betula nana*. We show that warming leads to a 28% and 22% reduction in the richness of soil fungi and bacteria, respectively, agreeing with reductions in plant community richness with warming at this site, and suggesting that warming will reduce total community diversity in tundra. Together, these results strongly suggest that soil microbes play a critical role in plant community dynamics and C-cycling in Arctic tundra, and that this role will become increasingly important as climate warms.

Soil Resilience and Soil Change: Lessons from Natural Experiments on Multiple Time Scales

Paul Sanborn
University of Northern British Columbia

Soil resilience is a practical concern for land managers because they need to know the limits of their actions – the "points of no return" – beyond which productivity may be lost beyond repair on humanly-relevant time scales. For the past thirty years, forest soil scientists in our region have learned much about where these points may lie, and have developed tools for avoiding and repairing damage to soils. We have also established and maintained field experiments to help us understand how these tools work, and how they can be improved. We are also beginning to grasp that some level of soil disturbance, anthropogenic or otherwise, has a role in sustaining site productivity.

During this same period, ecologists have developed a sophisticated understanding of the frequencies, magnitudes and patterns of disturbance processes in forests. This is now reflected in the way we educate foresters – they learn silviculture by first studying natural disturbance ecology. Disturbances aren't demonic interventions; they are just part of the way the world works.

These recent changes in how we understand forests and their soils have occurred largely independently of each other, yet are remarkably parallel. It is also apparent that pedology – the study of the genesis, distribution, and classification of soils – has been slower to follow this conceptual pathway. It was only five years ago that a major textbook first devoted a separate chapter to soil disturbance processes and their pedological implications. Yet when we consider these processes on pedological time scales – decades to millions of years – and enlarge our perspective to consider irreversible soil changes, we gain essential context for our management actions and the basic science of forest soils.

Using examples of natural experiments in soil formation, I will show how a pedological perspective can inform the way we view soil resilience and change on multiple time scales in our region. These experiments involve what are better termed "soil arrays" rather than chronosequences, because natural disturbance processes make many of these examples depart considerably from the requirements of classical chronosequences.

The geological youthfulness of our forest soil landscapes provides a degree of geochemical resilience that we usually take for granted. This youthfulness is created and maintained by events that can be big and slow (continental glaciations), small and fast (volcanic eruptions, landslides) and small and slow (aeolian dust deposition). In the absence of these events, in otherwise highly productive environments (mild and moist), subtle initial features of soil parent materials can trigger a downward spiral of ecological decline. In other settings, parent material characteristics can amplify the retarding effect of extreme cold and/or aridity on soil change and ecological succession.

Use of the Proctor test to evaluate compaction response and resilience of forest soils in British Columbia

Chuck Bulmer, Yihai Simon Zhao and Maja Krzic

Abstract:

The Proctor compaction test is most commonly used to evaluate the compaction state of soils in engineering applications such as road construction, but the method has also been used to evaluate the effect of soil compaction on forest and agricultural productivity. The Proctor test returns a value for maximum bulk density, which can be used as a reference value to determine the relative compaction state of a soil. Several authors have previously reported that, for many soils, the maximum bulk density value determined by the Proctor test was related to soil particle size distribution, but no such relationship was observed in recent studies evaluating the maximum bulk density of forest soils from a wide range of locations in BC. We will explore these contradictory responses in relation to soil organic matter levels and pedogenic structure development. The potential implications for soil resilience will also be discussed.

Site Productivity Following Various Levels of Biomass Removal at Fall River LTSP: 10 year productivity

Scott Holub - Weyerhaeuser, Albany OR scott.holub@weyerhaeuser.com
Tom Terry – Weyerhaeuser (ret.) / USFS Volunteer, Olympia WA
Rob Harrison - University of Washington, Seattle WA
Connie Harrington - USFS, Olympia WA

Abstract:

The Fall River LTSP (Long-term Soil Productivity) site in western Washington state is an affiliate to the national network of LTSP sites. Harvest treatments at Fall River included 4 levels of biomass removal ranging from operational (Bole only) to a complete removal of all logging debris and legacy coarse woody debris. Weed control, compaction, and compaction with tillage were additional treatments. Planted in the spring of 2000 with 1+1 Douglas-fir, Fall River completed its 10th growing season in the fall of 2009. After 10 years, the 4 harvest treatments were within 5% of each other in both basal area and height. Weed control had a substantial effect on tree growth increasing basal area 24% and height 8%. The disturbance/compaction treatments applied did not negatively affect tree size, while tilling compacted soil had no positive effect. Overall, the growth of trees at Fall River appears to be unaffected by harvest level or compaction which indicates that this site is probably robust to the kind of disturbance treatments that were applied.