From the Director

By the time you receive this we will have had the SMC Annual Spring Meeting. If you were unable to attend be sure to go to the SMC website to find the minutes and copies of presentations. Many of you may have been aware of the joint TAC meeting that was held on April 1 at the University of Washington to discuss information needs and research questions of SMC members regarding fertilization & nutrition. We had 35 attendees from 21 organizations engage in a lively and informative discussion which led to a number of action items for us to work on. These include several information syntheses as well as developing workshops and training events. The minutes of the meeting can be found on the SMC website: www.standmgt.org. This issue contains an article by AB Adams on Carbon Movement and Sequestration in SMC Type I Installations and a profile of Eric Sucre, a Masters student working with SMC Nutrition Project Leader Rob Harrison. Eric is completing a project of scanning all annual reports, publications, theses, etc. produced by the Regional Forest Nutrition Research program. Many of these are out of print and difficult to find. They will be placed on a set of CDs that will be available at a nominal cost in the near future.

Dave Briggs, SMC Director
Carbon Movement and Sequestration in SMC Type I Installations

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Ecosystem Science Division, University of Washington
Seattle, Washington

Introduction
An information source for Douglas-fir growth response has been the Regional Forest Nutrition Research Project (RFNRP) initiated in 1969. Information for soils in the installations is more limited. Earlier soil carbon (C) research in these Type 1 installations (Phase 1-3) was done by Peterson, Ryan and Gessel (1984). In the Pacific Northwest, soil carbon (C) is significant because boreal forest have the potential to mitigate the increase in atmospheric concentration of CO₂ (Lal, 2003) while remaining highly productive forests.

In this study, we considered carbon sequestration ca. 30 years after the initiation of repeated urea applications on second growth Douglas-fir stands in RFNRP installations in the foothills of the Central Puget Trough. Urea and soil type were treatment variables. Initially, our sampling was hindered by a lack of precipitation during the winter of 2000-01 (Fig. 1); however, the summer of 2001 and winter of 2001-02 had normal to above average precipitation. This provided us with a simple means of comparing the relation of water and DOC flux in our study region.

Sample Collection and Methods
Methods are described in detail in Adams, et al. (manuscript in review).

Site Description and Treatments: Soils at two sites (Tables 1 and 2) were derived from glacial material. Site 1 was coarse outwash, and Site 2 was deep sandy outwash. Of the two volcanic soil types, Site 3 was coarse loamy ash above glacial outwash material, and Site 4 was a deep (>1 m) ashy loam, tephra mix. Control and urea (fertilized with 448 kg ha⁻¹ and then 224 kg ha⁻¹ every four years to a total application of 1142 kg ha⁻¹ urea) plots were chosen from each installation.
Field Soil Collections and Carbon of the <2mm Soil Fraction: Soil collections were made according to horizons located in the soil profile. All soil <25 mm and all rocks >25 mm were weighed as two separate components in the field. Sub-samples of the <25 mm component were taken for each layer identified in the field and used to determine field moisture and the particle size distribution. Bulk density (Db), was determined by displacement methods and hammer corer and measurements based on the location and nature of the soil (Blake and Hartge, 1986; Harrison, et al., 2003). The <2 mm material was finely ground with a mortar and pestle and analyzed for total C using a CHN analyzer.

Lysimeter Installations, Data Collection and C Flux: A zero tension pan lysimeter was placed under the forest floor. In addition, three negative tension lysimeters at depths of 15, 50 and 100 cm were installed (Titus and Mahendrappa, 1996) at each plot. Soil solutions were collected every 4-6 weeks. Hydrologic flux was determined using the Thornwaite method (Dunne and Leopold, 1978) to estimate potential evapotranspiration rates for each site, and then by weighing potential evapo-transpiration against precipitation to determine net soil-water flux. Coupled with C concentration data, we were then able to estimate C fluxes by depth (Table 3). Weather data for each site was extrapolated using local weather stations nearest to our sites (National Climatic Data Center 2003 and Washington Annual Precipitation 1998). For Site 1 we used the Landsburg Station, for Site 2 the Chimacum Station and for Sites 3 and 4 the Mud Mountain Dam Station.

Results and Summary
Characterization of Soil Physical Properties (Tables 1 and 2): The glacial soils are both coarse-textured, but Site 1 has a high proportion of material >25 mm, and only 10% of the material is <2 mm. The other glacial soil (Site 2) was predominantly (>70%) sand and had no material >25 mm. The volcanic soils were both silty loam. Site 3 is 40-50% < 2 mm and about 10% rocks >25 mm. Site 4 is 65-90% < 2 mm and has no rocks >25 mm. Bulk density values ranged from as low as 0.13 for forest floor samples to 1.65 for compacted sand in the Bm horizon of Site 2. Bulk densities were low (<0.4) for O horizons, and Db increased with depth. Forest floors (O horizons) were variable between sites ranging from scarcely present at Sites 2 and 4 to conspicuously present at Sites 1 and 3. Percent C was >30% in all forest floors except for Site 4 (the site with the most mineral soil C) (Fig. 2). At Sites 2, 3 and 4, forest floors were much smaller in treated plots relative to controls. This was probably because the urea fertilization increased decomposition rates.

Soil Carbon: At Site 1 the fertilized plot had 10% less C than did the control, but more C was found in treated pits at Sites 2, 3 and 4 (46%, 135% and 37% more C, respectively) (Fig. 2). The four glacial pits had significantly less carbon than the four volcanic pits (p=.008 for parent material effect in ANOVA). Most (>80%) C in coarse outwash was in the forest floor (Fig. 3). In the sandy glacial outwash soil C was distributed equally throughout the control, but yielded proportionately more in the treated Bs horizon (39% versus 24% or less in the other three horizons).

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<tbody>
<tr>
<td>Age</td>
<td>50</td>
<td>38</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Trees per ha</td>
<td>780</td>
<td>750</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Quadratic mean dbh (cm²)</td>
<td>22.61/27.66</td>
<td>19.91/20.70</td>
<td>31.88/32.69</td>
<td>30.10/30.78</td>
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<tr>
<td>HT100 (m)</td>
<td>26.2/29.1</td>
<td>19.9/20.7</td>
<td>28.7/26.4</td>
<td>27.6/27.1</td>
</tr>
<tr>
<td>Basal area (m² ha⁻¹)</td>
<td>38.65/48.97</td>
<td>33.07/49.08</td>
<td>51.28/51.82</td>
<td>50.95/53.34</td>
</tr>
<tr>
<td>Elevation (m)</td>
<td>320</td>
<td>140</td>
<td>646</td>
<td>555</td>
</tr>
<tr>
<td>Mean annual precipitation (mm)</td>
<td>125</td>
<td>90</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>Soil Series</td>
<td>Barneston</td>
<td>Poulsbo</td>
<td>Winston</td>
<td>Rugles</td>
</tr>
<tr>
<td>Location</td>
<td>S21 T22N R7E 47°23’N 121°55’W</td>
<td>S18 T27N R2E 47°49’58.01”N 122°36’11.44”W</td>
<td>S33 T20N 7E 47°11’N 121°51’W</td>
<td>S11 T19N R7E 47°8’48.75”N 121°43’4.22”W</td>
</tr>
</tbody>
</table>
Volcanic soil profiles had much higher C than the glacial soil profiles (mean 279 Mg ha\(^{-1}\) versus mean 61 Mg ha\(^{-1}\), respectively). Percent C was >30% in all forest floors except for Site 4 (the site with the most mineral soil C) (Fig. 2). The largest C difference in treated versus control pits was in the coarse silty loam soil (135% greater in the treated plot relative to the control). At this same site, however, the forest floor control had higher C (60 versus 12 Mg C ha\(^{-1}\)); again, this indicated that decomposition rates were higher in the fertilized plot. At this plot the large difference between the treated and untreated pits was

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Profile descriptions of soils at study sites</th>
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<tbody>
<tr>
<td></td>
<td>Horizon</td>
</tr>
<tr>
<td><strong>Site 1.</strong> Inceptisol, Poulsbo, coarse-loamy, isotic mesic Vitrandic Dystroxerept, slope 0-5%</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
</tr>
<tr>
<td>Bs</td>
<td>46</td>
</tr>
<tr>
<td>2Bsm</td>
<td>51</td>
</tr>
<tr>
<td><strong>Site 2.</strong> Andisol, Barneston, sandy-skeletal, mixed, mesic Typic Vitrixerand, slope 1-3%</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>7.5</td>
</tr>
<tr>
<td>A</td>
<td>13.3</td>
</tr>
<tr>
<td>Bs</td>
<td>41.5</td>
</tr>
<tr>
<td>2C</td>
<td>45.3</td>
</tr>
<tr>
<td><strong>Site 3.</strong> Inceptisol, Winston, coarse-loamy over sandy-skeletal, mixed, superactive, mesic Andic Dystroxerepts, slope 0-1 %</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>5.5</td>
</tr>
<tr>
<td>A</td>
<td>8.5</td>
</tr>
<tr>
<td>AB</td>
<td>23.2</td>
</tr>
<tr>
<td>Bs</td>
<td>47.5</td>
</tr>
<tr>
<td>2C</td>
<td>44.5</td>
</tr>
<tr>
<td><strong>Site 4.</strong> Andisol, Rugles, medial over loamy, amorphic over isotic, frigid Typic Hapludands, slope 0-5%</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>6.8</td>
</tr>
<tr>
<td>A</td>
<td>5.6</td>
</tr>
<tr>
<td>AB</td>
<td>5.3</td>
</tr>
<tr>
<td>Bw</td>
<td>51.8</td>
</tr>
<tr>
<td>BC</td>
<td>32.6</td>
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</tbody>
</table>

Figure 2: Carbon and nitrogen data for the <2mm soil fraction in 4 soil types ranging from coarse to fine-textured. Coarse soil had less total nitrogen. Treated plots had more nitrogen than control.
manifested in the A, AB and Bs horizons (15 versus 48, AB horizon not detected versus 123 and 27 versus 101 Mg C ha\(^{-1}\)) respectively. Site 4 (fine silty loam) showed the same trends as Site 3, but to a lesser degree. At Site 4 the forest floor control had more C (35 versus 20 Mg C ha\(^{-1}\)), and A, AB and Bs horizons in the treated plots had more C (47 versus 65, 39 versus 180 and 108 versus 131 Mg C ha\(^{-1}\)), respectively. The differences between treated and control plots are large. Due to our limited sampling, it is premature to assign C sequestration rates to these results since we do not know initial soil C values.

Soil N was higher in all fertilized plots (Fig. 2) indicating that effects from the urea applications were partially retained, but absolute quantity of soil N was higher in the volcanic soils (mean 3.2 for glacial pits versus 11.6 Mg ha\(^{-1}\) for volcanic pits). The percent difference in N for treated compared to control was higher at all sites (15, 10, 77.5 and 28% for Sites 1-4, respectively). This indicated that more N was lost from the system in the glacial material than in the volcanic. This could be due to leaching as well as plant uptake of inorganic N.

Dissolved Organic Carbon: The Puget Trough usually has dry summers, and with the onset of the fall rains it takes repeated rainfall events for soils to saturate to a depth of one meter; therefore, most of the C flux usually occurs in the winter and spring months. During the first winter of our study, however, lysimeter success rates, C concentrations and hydrologic flux were low relative to subsequent values for summer 2001 and winter 2001-02 (Fig. 4). Lysimeters at all 4 sites responded similarly to this hydrologic situation in that mg of DOC L\(^{-1}\) increased at all sites into an unusually wet summer with saturated soils and then into a wetter-than-normal fall and winter. These results suggested that water flux was positively related to C flux (Neff and Asner 2001). Carbon flux monthly rates were highest in the coarse glacial outwash and lowest in sandy glacial outwash (the latter also having the least precipitation during the study) (Table 3).

The highest DOC flux values were in forest floor lysimeters at treated plots except Site 3 where the highest DOC flux occurred in the treated plot at −15 cm rather than the forest floor. Most of the quantitative decrease in DOC occurred between
the forest floor and −50 cm, yet the percentage change from −50 cm to -100 cm was still >140%. At all sites, DOC flux decreased markedly with depth; nonetheless, up to 5 times as much C leached to -100 cm in coarser glacial material than the other. The percent C leached to −100 cm was much higher for the glacial soils (mean of 12.4% for glacial versus 3.7% for volcanic).

Conclusions and Summary
The <2 mm fraction in coarse-textured glacial soils of managed second growth Douglas-fir forests had significantly less C stored than fine-textured volcanic soils. Urea treated plots had more C than controls in the silty loam volcanic sites, and this difference was greatest for the coarse silty loam. The most C and N were in the fine silty loam fertilized plot. Due to our small sample size, these differences were not significant; nonetheless the magnitude of the differences is impressive.

We found an inverse relationship in the differences in C in forest floor organic soil versus C found in soil at deeper depths. Similarly, forest floor organic soil had less C in treated plots relative to controls in plots with high quantities of deep C. This suggested that decomposition was accelerated by the fertilizer application. This can explain a source of some of the C increase in the lower horizons, but there is still much more C in the deeper treated plots than can be explained by the O horizon alone. Aerobic respiration can cause a loss of as much as 2/3 of the soil C via CO2 evolution. The larger quantities of C detected in the treated plots were located in the A, AB and upper B horizons, not the forest floor.

Weather patterns (a dry winter in 2000-01 followed by a wet summer and winter) correlated with C flux on a regional basis (i.e., total C flux increased with soil saturation and high water flux). The quantity of DOC leached was much larger in the wetter winter of 2001-02 than winter 2000-01. Although C leaching was 5 times higher in coarse glacial soil, the absolute quantity lost to leaching below a meter is only a small proportion of the total DOC produced by the forest floor. Perhaps in coarser soils with greater aeration, more C is lost to respiration, since it was not detected in the <2 mm fraction. Our results lend credence to the sorption equilibrium mechanism of C flux between the soil solution and soil phase (Qualls, 2001).

Sampling of the lysimeters is continuing throughout winter 2003-04.

Acknowledgements
Research supported by the U.S. Department of Energy’s Office of Science. Oak Ridge National Laboratory is under contract DE-AC05-00OR22725 and Prism Program (Jeff
Richey) (UW). We thank Weyerhaeuser, The Campbell Group, The Hancock Co., Champion Pacific Timberlands and City of Seattle for access to sites. This project would not have been possible without the SMC staff.

References

Figure 4: Mud Mountain summary graph of Thornwaite equation output used to determine net water and carbon flux for each plot. Total DOC (Mg L-1) for the forest floor is also plotted to show the increase in absolute DOC concentration in winter 2000-01 compared to summer 2001 and winter 2001-2. All 8 plots exhibited this trend of increasing organic C flux in a wet spring and summer after a dry winter (see Fig. 1). This is evidence for sorption equilibrium with the solid soil phase.
Upcoming Meetings and Events

May 12-13, 2004 – Forest Seedlings Root Development from the Nursery to the Field, Eugene, Oregon. For more information please visit the Western Forestry web site: www.westernforestry.org, or contact aimee@westernforestry.org.

June 1, 2004 – Exploring Stand Density and its Relationship to Wood Value, Vancouver, BC, Canada. For more info please contact Jennifer Turner: jennifer.turner@forrex.org.


September 23-24 – 2004 Stand Management Cooperative Fall Meeting. This year’s fall meeting will be held as a joint meeting with the Western Forestry & Conservation Association meeting: Effects of Management Practices on Productivity of Western Forests: A Forest Products Focus. The meeting will be held in Olympia on September 20-23. For more information on the Western Forest meeting please visit http://www.westernforestry.org/. More information regarding the SMC meeting will be posted on the SMC’s web page: http://www.standmgmt.org.


Abstracts and Publications


Abstract
This memo provides information on the biological and economic response of Douglas-fir to fertilization, which (along with a good knowledge of other silviculture activities) should help to develop sound fertilizer prescriptions.

For more BC publications, a good place to start is the BC Ministry of Forest Research Branch publications web site: http://www.for.gov.bc.ca/hre/pubs/.


Abstract
The influence of shade tolerance, canopy position, and tree size on growing space efficiency (GSE) in mixed stands of co-occurring conifer and hardwood species was investigated in hemlock–northern hardwood forests. Three alternative measures of two-dimensional growing space—total crown area (TCA), exposed crown area (ECA), and a projection of the total available growing space (AGS)—were investigated to clarify the comparative importance of shaded and illuminated crown regions and unoccupied space in the forest canopy. GSE was expressed as ratios of stem volume increment and biomass increment per unit of growing space.

Late-successional, shade-tolerant species have often been portrayed as slow growing, inefficient
users of their growing space; however, hemlock (Tsuga canadensis), which is one of the most shade-tolerant conifers in North America, was the most efficient canopy tree in our sample across all measures of GSE. Likewise, the mid-tolerant yellow birch (Betula alleghaniensis) tended to be less efficient than the more shade-tolerant maples (Acer rubrum and Acer saccharum). For all species, volume increment per unit of growing space increased with increasing tree height and canopy position, but within a given stratum decreased with increasing crown size. The relative efficiency of each species did not appear to be influenced by the measure of growing space employed. In most cases, volume and biomass increments per unit of ECA and AGS were significantly greater (p<0.05) for intermediate than dominant crown class trees. However, for a given level of ECA or AGS, efficiency did increase with increasing relative height, which suggests that efficiency is influenced by the relative vertical position of growing space in the forest canopy. In general, the shaded area of a crown (i.e., TCA-ECA) was not a significant predictor of volume increment once height and ECA were known, suggesting that once 100% canopy closure is reached, packing trees more tightly may not increase stand-level production. However, mean volume increment per unit of TCA scaled more accurately to the stand-level than mean volume increment per unit of ECA. Potential scaling problems associated with mixed-species stands are discussed.


Abstract

This study looked at the effects that multi-nutrient fertilization had on understory vegetation nutrient concentrations at four conifer forested locations in the inland Northwest. Multi-nutrient fertilization of conifer stands cannot only enhance the overstory species in the inland Northwest but also the understory vegetation. Determination of nutrient concentration response to fertilization treatments can provide managers the ability to better manipulate their forests for grazing and wildlife habitat. We grouped the understory vegetation into three general life forms: forbs, grasses and grass-likes, and shrubs. Multi-nutrient fertilization had little effect on nitrogen concentration across all life forms. Potassium and sulfur generally increased in concentration. Micronutrients as a whole showed less variability in response to multi-nutrient fertilization. Boron, copper, molybdenum, and zinc generally showed increases in concentrations across all life forms. We were able to conduct analyses on a selected number of understory vegetation species. Individual species showed variability in nutrient concentration response to multi-nutrient fertilization. Wildlife habitat and grazing quality were both increased and decreased following multi-nutrient fertilization. Increases in nutrient concentrations will provide more nutritious vegetation to these animals and vice versa for decreases in concentrations.


Abstract:

Remeasurement data over a period of 35 years from fourteen 0.2023-ha permanent plots were analysed to determine the growth and yield effects of commercially thinning 50-year-old Douglas-fir stands on a good site on Vancouver Island, British Columbia. Compared to unthinned stands, the commercially thinned stands had:

• virtually the same total volume gross annual growth, top height, and top height growth;
• 12% more potentially usable total volume yield (including thinnings);
• 18% less total volume at final harvest age 86;
• virtually the same crop-tree (193 largest-diameter trees per hectare) average diameter, but 24% larger entire-stand quadratic mean diameter; and
• 11% less total volume production lost to mortality.
These results show that commercial thinning slightly increased total stand yield (including thinnings) and produced larger diameter trees at rotation age 86, but that it also reduced usable total volume at final harvest and had virtually no effect on size of the crop-trees. Data from this study are useful for validating growth models, and for constructing and comparing managed stand yield tables for various commercial thinning regimes. Availability: http://www.for.gov.bc.ca/hre/pubs/pubs/1233.htm.


Abstract
A broadly-based, intensive Douglas-fir fertilization experiment throughout southern coastal British Columbia was used to examine 3 and 6 year crop tree growth responses to prescribed fertilizer applications. Absolute and relative basal area responses were evaluated in relation to site associations of the provincial ecosystem classification system, site index, and a large number of site and stand chemical and physical properties. Few of the site and stand variables examined as possible response prediction criteria appeared to have any real utility. The strongest relationships found were between relative basal area response and (1) site index ($R^2 = 0.46$ for both 3 and 6 year responses), (2) mineral soil mineralizable-N ($R^2 = 0.50$ and 0.46 for year 3 and 6 responses, respectively), and 3 total mineralizable-N ($R^2 = 0.47$ and 0.50 for year 3 and 6 responses, respectively). In all cases average relative response declined with increasing site quality. However, there were highly productive sites (S150 • 35 m) characterized by an absence of growing-season water deficits and relatively low foliar N concentrations (12–13 g/kg) showing significant fertilizer responses. These sites are where the greatest financial returns from fertilization may be realized. Relationships identified between site and stand variables and basal area responses were, in many cases, different from those found by other researchers for coastal Douglas-fir. This brings the portability of identified relationships into question.


Abstract
Phase 1 of this study (Utzig and Walmsley 1988) outlined the nature and extent of soil degradation effects on forest productivity in British Columbia. This report constitutes phases 2 and 3 of the overall study.

The objectives of this report were to outline appropriate research needs and strategies, to evaluate current legislation, policies and regulations and to examine the adequacy of staffing levels and training programs to deal with the identified concerns.


Abstract:
Two mixed-species spacing trials were established in central Oregon to test the effects of species composition and initial spacing on stand growth, yield, and structural development. One trial was composed of Pinus contorta Dougl. ex Loud. and Pinus ponderosa Dougl. ex Laws. and the other Abies grandis (Dougl. ex D. Don) Lindl. and P. ponderosa. Spacing, species composition, and age all had large influences on standing volume and periodic annual growth. In both studies, standing volume and periodic annual increment decreased with increasing spacing. In mixed plots, the least shade tolerant species had the fastest early growth rates, while the more shade tolerant species had the slowest.
Over time, initial differences in volume growth rates among plots of different species composition decreased. Relative yields in mixtures of *P. contorta* and *P. ponderosa* indicated no yield benefits. Mixtures of *A. grandis* and *P. ponderosa*, however, resulted in relative yield totals greater than one at all spacings. Spacing and species composition play an important role in stand production and development, and mixtures can yield similar if not more volume than pure stands of the higher yielding species at some spacings and stages of stand development.

**Student Bio**

**Eric B. Sucre, University of Washington M.S. Candidate in Forest Soils, CFR**

Ever since I was a kid, I knew that I wanted to pursue a career dealing with the environment and the outdoors. I grew up on a farm in Madison County, which is located in Western North Carolina near Asheville. I began my college career as an Environmental Engineering student at North Carolina State University. After two years in this program and an amazing trip to the western US, which consisted of backpacking through a dozen National Parks for 90 consecutive days, I knew that I wanted to pursue a career in Forest Management.

I graduated with a B.S. degree in Forest Management from NC State University in the spring of 2003. I developed a comprehensive management plan for a 1200 acre tract of land owned by a local utility company, which emphasized timber management, longleaf pine restoration, and wildlife management during my senior year. I also worked as a Forest Engineering research assistant, where I examined several different tree planters.

I knew that if I wanted to be a well rounded forester, it would be beneficial for me to see how forest management practices are both similar and different on the west coast versus the east coast of the US. I joined the College of Forest Resources Community last fall as an M.S. candidate in Forest Soils. I have always had an interest in soil science and this is one of only a few places where there a degree in Forest Soils is offered. Rob Harrison, Dave Briggs, and Eric Turnblom are my committee chairs. I have been working on the RFNRP Synthesis project thus far and have developed a “Compilation CD series” of the various work associated with the RFNRP. I am grateful for this opportunity to be working and learning here in the PNW and one day I would like to work with a private forestry consulting firm.

In my free time, I like to compete in road races, backpack, travel, listen to music and cook.
New Equipment for CFR Soilslab

The University of Washington Soilslab just received a Shimadzu high-sensitivity total inorganic and organic C (DIC and TOC) and total N (TN) analyzer that will allow for the accurate, economic and efficient analysis of C and N in solution. The addition of this piece of equipment to the Analytical Services Laboratory will allow for further research into C and N mobility in forest soil systems, specifically to aid research regarding N leaching and C sequestration in conjunction with our forest soils lysimeter work. Pictured here with the machine are 2 soils graduate students; Brian Strahm and Tina Jensen.