WSCS/WSSS Annual Meeting Field Trip

8:00 am to 1:00 pm, Wednesday, June 22, 2011

Soils, Agriculture, and Mountain Pine-Bark Beetle Ecology of the Laramie Basin, Centennial Valley, and Snowy Range

Dr. Larry Munn, Pedologist, University of Wyoming: Laramie Basin and Snowy Range.

Dr. Urszula Norton, Soil Biogeochemist, University of Wyoming, and PhD Student Bujidmaa Borkhuu: Impacts of beetle-induced forest mortality on carbon, water and nutrient cycling.

Wednesday's field trip will begin in the western Laramie Basin on the X Bar Ranch where "wild flood" irrigation is used to irrigate Garrison creeping foxtail hay meadows. This is a typical agricultural practice in this 7500-foot elevation semiarid basin. The trip continues through Big Hollow; the largest deflation basin in North America, where high winds during the late Pleistocene turned a ridge of hills into a basin lower than the ancestral stream deposits around it. We'll examine rangeland aridisols and a highly developed petrocalcic horizon on one of these old stream terraces. Then we'll continue up Wyoming Highway 130 into the Snowy Range to observe soils of the Pinedale and Bull Lake glacial tills.

The trip will proceed up the snowmelt-swollen Libby Creek through the recently opened slot through record snowpack two to three meters deep to the summit at Libby Flats. After observing high-mountain landforms and processes, we'll travel back to old mining town of Centennial and south to Wyoming Highway 230 and the last stop at a Mountain Pine Beetle ecological research site near Chimney Park. Here University of Wyoming scientists will describe research on how the massive forest mortality is impacting water, carbon, and nitrogen cycling.

A detailed guide of the trip follows

Stop 1. Irrigated Hayfields, Phallow Strath surface. The surface here is an old river channel from the (big) Laramie River. Approximately 250,000 years ago, the Laramie River was apparently "captured" by a smaller stream which was one of its tributaries to the south and this channel was abandoned. The alluvium on this surface is relatively thin (1 to 2 m thick) and the underlying bedrock is saline, Cretaceous age shale. The soils on this surface exhibit problems with salt build up if irrigated.

This site receives an average of 26 to 27 cm of precipitation annually. On the prairie, "annual" precipitation doesn't mean much because of the large variation in year-to-year values, and because of the redistribution of water as blowing snow. The potential evapo-transpiration is much greater than precipitation at this site, as evidenced by accumulation of carbonates and salts in the soil.

Compounding this natural limited leaching, soils in this area have been affected by irrigation water which seeps from the Pioneer Canal to the north of the area. The canal which was dug in 1890 cuts into the Niobrara shale- a dark Cretaceous age shale which was built up in a marine environment and is usually quite saline. The greasewood (Sarcobatus vermiculatus) on the site accumulates Na around the base of the plant as its leaves fall and is a reliable indicator of high electrical conductivity (10 or more dS per m). Groundwater from shallow wells on this surface are extremely saline (1000 ppm on up) and most people who live on the west side of Laramie on this surface have cisterns and haul water from town. The soils on this surface were originally mostly Calciargids but as the salt has accumulated and is building in the old root channels, greasewood and saltgrass have invaded the native range and abandoned wheat fields. Most of the soils do not yet have the 2% salt required to define a salic horizon. The irrigation water is of good quality (mountain snow melt water with low salt) until it seeps through the shale.

The State Land Board did a number of trades of small isolated parcels of state land a few years ago to consolidate together a 16,000 acre property, the X Bar Ranch, and which is leased for commercial agriculture. In addition to a small cow-calf herd, the X Bar operators bring in hundreds of yearlings in the winter which they feed out on the hayfields which the wind blows free of snow. Hay production is mostly Garrison creeping foxtail which does well under a regime aptly described as “wild flooding”. Production is approximately 2 tons/acre.

Along the road: entering Big Hollow. The soils exposed along the road cuts are Entisols developed in residuum. These soils show a thin profile with weak horizonation- C, Cr. The epipedon is ochric and there are no diagnostic subsurface horizons, although there is a contact to soft bedrock (Cr horizon material) called a paralithic contact. The soil is a Typic Torriorthent, fine, smectitic, frigid, shallow. The term "shallow" indicates a paralithic (soft rock) contact at less than 50 cm depth. The soil is relatively "young" because of continual erosion at the site. The Cr horizon here is somewhat weathered Frontier Shale. The Frontier is a Cretaceous marine formation that is mostly dark shale high in sulfur, with some inter-bedded sandstone. It produces a clayey soil that often contains gypsum and may range in pH from 4.0 to 9.0! The Twin Buttes to the west have quartzite cobbles on the alluvial surface which indicates that the Little Laramie River came this far south at one time since the only source for quartzite locally is the top of the Snowy Range (Medicine Bow Peak is an old beach, about 2 billion years old).

The Big Hollow is the largest deflation basin in North America. It has to be younger than the alluvial valley floors which now form its boundaries and is therefore of Late Pleistocene age (less than 250,000 years). During most of the Pleistocene the Big Hollow was actually a hill composed of soft sedimentary bedrock. The material making up this former hill was much more easily eroded than the alluvial valley floors which bounded it to both the north and south. Eventually, the hill was washed and blown away and then the wind continued to erode a deflation basin into the soft bedrock. Eventually the former hill became lower than the river channels which once flowed around it. The geologists call this "topographic reversal".

Stop 2. Aridisol with argillic horizon and Aridisol with petrocalcic horizon.

This stop shows about the maximum expression of carbonate accumulation in Wyoming. The soil in the small depression is a coarse-loamy, mixed, frigid Ustic Haplocambid. There is not enough calcium carbonate to form a calcic horizon although there are some carbonate films and the matrix is weakly calcareous at depth. The soil is much younger than the soil on the flat, high surface into which the channel has incised. On the old surface (viewed courtesy of the abandoned railroad to North Park), the soil is a Typic Petrocalcid, loamy-skeletal, carbonatic, frigid. There is so much carbonate in the layer overlying the petrocalcic horizon that it qualifies as a calcic horizon. Horizons are Ak, Bk, Bkm, Bk', 2C. The surfaces where this soil occurs are all on the order of 1,800,000 years plus. This Bkm horizon material is what the locals refer to as "caliche" in the Southwest. The laminar layer at the top of the Bkm indicates that water no longer penetrates it at all. The original parent material here was quartzite-rich alluvium from the Little Laramie River and the carbonate accumulation represents a tremendous accumulation of dust over time. These petrocalcic horizons are a very effective "armor" against erosion for the old valley floors. Both the Eagle Rocks surface (with the repeating tower) and Table Mountain (the small mesa off the northeast end of Sheep Mountain) are still extant because of the protection afforded them by the petrocalcic horizons and alluvial cobble channel deposits which occur on them.

Snowy Range Glacial Till Soils.

Stop 3. Bull Lake till above Centennial.

The Bull Lake age till (ending approximately 140,000 years before present (YBP), corresponding to the Illinoian continental glaciation) is now rounded and well dissected by small ephemeral channels. Rocks in the till are predominately quartzite and other metamorphic rock from the core of the Snowy Range. The underlying bedrock at the site is Cretaceous age sedimentary rock. In addition to the development of a grassland soil (Mollisol, a Typic Argicryoll) at this site, two things of note have occurred: the "smoothing" of the landscape by erosion and the weathering out of soft rock in the till, leaving a higher proportion of quartzite. Compare these features with younger (25,000 to 15, 000 years old) Pinedale tills (Late Wisconsin age) which we saw at a later stop on this field trip.

Stop 4. Inceptisol developed under forest on Pinedale moraine.

This cut along the ridge of a lateral moraine exposes several characteristic horizons of forest soils of this age in the northern rocky Mountains. The horizon sequence is : Oi, E, Bw, C. The Oi layer is a thin mat of pine needles, twigs, bark , etc. The small “i” indicates that the material is only slightly decomposed, and its origin is readily apparent. The ashy gray colored E horizon is very typical of the "topsoil" layer of forest soils developed under coniferous forest. Organic acids in the water percolating from the litter layer above enhance leaching of iron, aluminum, clay and other constituents from the surface of the mineral soil. E indicates an "eluvial" or leached out layer. The soil is an Inceptisol (Typic Dystrocryept, loamy-skeletal, mixed). The loamy-skeletal soil textural family indicates that the soil has less than 35% clay and more than 35% rock fragments (greater than 2 mm). Mixed indicates that no one clay mineral predominates. pH of the E horizon was 5.1.

The brown Bw horizon in the subsoil is representative of soils of this age (late Wisconsin, approximately 15,000 YBP), that is Pinedale in the Rocky Mountain chronology. The Bw horizon shows some weathering in the form of a brighter color due to release of iron from the minerals in the till. The layer also has weak subangular blocky structure. A few of the softer rocks have started to weather, but the rock fragments represent different lithologies from the various strata the glacier passed over. The C horizon is relatively unaltered till. It shows the mix of particle sizes, without stratification (such as you see in stream alluvium), from clay to boulders. The Pinedale till here is usually of cobbley loamy sand texture (6 to 8 % clay). The Bw horizon of this soil has slightly more clay than usual for cambic horizons in soils of this age, perhaps 12 to 14%. This is due to the high schist content of the till which rapidly weathers to clay (illite). Only very weak evidence of clay translocation is apparent in this soil (i.e. no clay films or argillans on ped faces but thin films on pebbles). Weak structure of the Bw horizon reflects the low clay content. The E horizon also has a similar clay content.

This soil is less productive as a growing site than the Alfisol that we will see at the next stop because the coarse texture and rock content limits water holding capacity. The soil at the site would be resistant to compaction by logging equipment however, whereas a finer textured, non-skeletal soil might be compacted if trafficked when wet.

Stop 5. Alfisol on pre-Bull Lake till. The soil at this site gives the appearance of a soil developed under intense weathering conditions in a climate much warmer than that of the present. The soil exists along both sides of the Rock Creek Ridge wherever it was not wiped out by younger glacial activity (Bull Lake and Pinedale glaciations) in the area. The soil is thought to be approximately 0.5 million years old. It has an ochric epipedon and an argillic horizon, and is classified as a Typic Haplocryalf, fine-loamy, kaolinitic. Clay content in the Bt varies between 25 and 35 %.

This soil looks very much like the Ultisols of the subtropics and southeastern U.S.A. The parent material was probably till or glacial outwash but it has been intensively weathered until only quartzite rocks remain. In the acid regime of this soil (pH 4.3 to 4.8 in the subsoil) only kaolinite is a stable silicate clay. The red color comes from an iron oxide coating on the surface of the mineral grains.

Vegetation at the site is lodgepole pine and Engelmann spruce, with some subalpine fir also. At this elevation, the spruce and fir usually reach large size on north facing slopes and crowd out the lodgepole pine between fires due to a longer fire cycle. On south and west aspects, lodgepole regrows after fires with a shorter interval. Despite the relatively low fertility at this site, climate is probably the major limitation to forest productivity; the site has a high capacity to supply plant available water. The supply of weatherable minerals in the E has been depleted by weathering over time and new clay is only now being very slowly formed at the top of the Bt horizon.

Along the road. Libby Flats observation point. This area is where the Nash dolomite bedrock isexposed along the path to the observation tower. The clumps of flagged trees are called krumholz communities. They represent an adaptive growth form in a very harsh envirorment.

Stop 6. Top of The Range. Protalus Rampart below Medicine Bow Peak. The twin ridges of quartzite blocks which stand out from the base of the crest are Neoglacial deposits. The high ridge of the Snowy Range is a white quartzite that is the most durable rock in the southern part of the state. During glacial times, snow and ice accumulated against the face of the ridge and when the ice reached sufficient thickness, its weight caused it to flow out over Libbey Flats and then to channel down the Libby Creek and North Fork canyons where we observed the till soils. The ridge is the source of the quartzite in the tills and in the alluvium from the Little Laramie River.

Two steep ridges of quartzite rubble parallel the bedrock ridge. This is a Neoglacial deposit (4000 YBP) that takes the form of a "protalus rampart" although it is somewhat lobe shaped as would be expected for a moraine. During the cold period known as the

Neoglaciation, a large snow and ice bank developed along the bedrock ridge. Blocks of quartzite which loosened on the rock wall from frost action fell and skidded on the snow field until they came to rest at its base. Years of this built up a ridge of blocks at the foot of the snow bank. After the climate warmed and the snow bank melted, the protalus rampart was left standing out in front of the rock face. The Neoglacial deposits show only very weak soil development. A lower ridge east of the high rampart may be the last Pinedale moraine or represent something in between in age. There are small talus piles below the peaks of the crest that may represent the 1200 to 1850 vintage "Little Ice Age" that is well recorded in Europe. The last ice advance in the Rockies seems to have been around 1850. It didn't amount to much and the relict glaciers have been melting rapidly since 1900.

The soil above treeline has a dark colored A horizon (15 to 30 plus cm) over a very weak Bw horizon or simply a C horizon. The A horizon is thick enough to allow the epipedon to be a mollic epipedon, however the base saturation is low (less than 50%) and so the epipedon is umbric. The base saturation is low (approximately 25%) since so much of the parent material is quartzite and the soil is well leached by 2 meters plus of snow that accumulates and melts each year. The soil is subject to quite a bit of mixing by pocket gophers that have left tunnel casts on the ground surface after the snow melts. These rodents move quite a volume of material over the years. The soil is a Humic Dystrocryept, loamy-skeletal, mixed. The humic subgroup modifier indicates the umbric epipedon and the dystro great group modifier indicates a low base saturation. The loamy skeletal is somewhat misleading since the soil appears to consist of silty material with few coarse fragments filling in between coarse blocks of rock. The soil itself is formed from the windblown material rather than weathering of the big blocks of rock.

Stop 7: Impacts of beetle-induced forest mortality on carbon, water and nutrient cycling in the Rocky Mountains

Project scientists Assistant Professor Urszula Norton and PhD Student Bujidmaa Borkhuu will describe research approach, apparatus, and early results at a primary data collection site for this state-of-the-art biogeochemistry research.

Conifer forests across western North America are undergoing a widespread mortality event mediated by an epidemic outbreak of bark beetles of the genus *Dendroctonus* and their associated bluestain fungi (*Ophiostoma* spp.). As of late 2009, beetles had impacted over 600,000 hectares in northern Colorado and southern Wyoming (US Forest Service aerial survey estimates), with the majority of mature lodgepole pine (*Pinus contorta*) and Englemann spruce (*Picea englemanii*) expected to be dead by 2012. While bark beetles are native to North American forests, the importance of insect outbreaks on water, C and N cycling has increased in recent years as a result of past timber management, fire exclusion, recent warming trends and drought. A recent modeling study suggests that CO_2 emissions from beetle-induced lodgepole pine mortality may be similar in magnitude to stand-replacing fires.

As this epidemic continues, we seek to improve our predictive understanding of coupled water, C and N cycles by quantifying how these cycles may become uncoupled in response to the outbreak. Our specific questions are 1) how does the rapid drop in individual tree transpiration impact the temporal and spatial extent of evapotranspiration and 2) how does the subsequent increase in soil moisture and lower C inputs and N uptake impact soil C and N fluxes?

The first impact of the bark beetle and blue stain fungi is a greater than 50% reduction in transpiration per tree within a month of infection. This change occurs even before the needles begin to turn red. The annual C sink declined by 80% from 2006 to 2009. Annual evapotranspiration (ET) now has an inverse relationship with precipitation; the last two years have seen a dramatic decrease in ET while precipitation has increased. Soil moisture has increased up to 100% within one growing season. Soil respiration has declined likely from lower labile C inputs while CH_4 consumption has decreased due to higher soil moisture. N_2O fluxes have increased with mineral N availability. Our results suggest that C, N and water cycles have become decoupled within two years of infestation.