B51A-06 0930h

The Ecohydrological Interactions Between Mesquite and its Water Sources

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Velvet mesquite (*Prosopis velutina*), a native woody plant to southern Arizona, USA and Sonora, Mexico, has successfully expanded its range and encroached into both upland and riparian grasslands during the 20th century. In this study, we examined the interactions between mesquite and its water sources in order to determine how the trees responded to moisture availability. This study took place in a riparian area and because the trees had access to both deep groundwater and surface water, these interactions resulted in important hydrological and ecological consequences. Surprisingly, we found that the mesquite responded to and even manipulated both surface and deep soil moisture even though they apparently had access to a stable groundwater source throughout the growing season. During dry season nights, observations of root sap flow showed that the trees moved moisture upwards in the taproot and out into the surface soils in lateral roots. As a consequence of this "hydraulic lift", diurnal soil respiration measurements showed that the soil microbes were stimulated following the nocturnal release of moisture into the near-surface regions. During rainy season nights, there was sap flow movement toward the tree in the surface lateral roots and downwards in the taproot indicating "hydraulic descent". Borehole GPR measurements of the deeper, 2 - 10 m, vadose zone moisture content increased apparently as a result of this tree-facilitated water movement. Also, hydraulic descent influenced water table elevations indicating direct groundwater recharge via plant pathways.

B51A-07 0945h

Assessing the role of spatial pattern in governing ecohydrological interactions and vegetation dynamics in semi-arid savannas.

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The spatial pattern of vegetation is both a cause and effect of variation in resource availability in semi-arid ecosystems. At landscape to regional scales, climatic and geologic constraints on soil moisture and nutrient availability are primary determinants of vegetation structural pattern in semiarid ecosystems. Similarly, at local to landscape scales, the patchy vegetation structural mosaic serves to redistribute the availability of soil moisture and nutrients in ways that have important consequences for structural dynamics and community composition. A coupled energy and water balance approach was previously used to simulate the effects of large tree canopies on soil moisture and water stress across a series of sites spanning a regional moisture gradient in southern Africa. Results from the model indicate that tree canopies serve to reduce soil moisture stress of under canopy vegetation in the middle of the rainfall gradient, while at the dry end of the rainfall gradient the effect of tree canopies on soil moisture is dependent on the amount of rainfall received in a given growing season. These findings are used within a modeling framework to assess the relationship between vegetation pattern and subsequent structural dynamics of mixed tree/grass ecosystems in southern African savannas. Special attention is given to the potential for woody vegetation encroachment in southern African savannas under varying levels of climatic change and altered land tenure.

B51B MCC: 3002 Friday 0800h

Soil Carbon Changes With Biomass Removal *(joint with A, GC)*

Presiding: **R Follett,** USDA Agricultural Research Service**; J Kimble,** USDA Natural Resources Conservation Service

B51B-01 0800h INVITED

The Effects of Residue Management on Soil Carbon Sequestration in the U.S. Cropland

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The cropland area in the U.S. is 157 Mha or 17.1% of the total land area of 916 Mha. Of this, 119 Mha is rainfed, 22 Mha irrigated and 16 Mha idle cropland. Some steeplands and other marginal soils are prone to accelerated erosion and other soil degradative processes. Total cropland are subject to accelerated erosion is 44 Mha, and secondary salinization occurs on 0.2 Mha of irrigated cropland. Conversion of plow till to conservation tillage, residue management, incorporation of cover crops in the rotation cycle, integrated nutrient management, and restoration of degraded soils are among the recommended management practices to sequester C and improve soil quality. The potential of soil C sequestration in the U.S. cropland is 45 to 98 Tg C/y for adoption of recommended management practices, 9 to 13 Tg C/y for CRP, and 13 to 31 Tg C/y for restoration of eroded cropland. This potential is contingent upon return of crop residue mulch and other biosolids so that C input into the soilscape exceeds the C losses by mineralization, erosion and leaching. However, with growing interest in alternate uses of crop residues (e.g., biofuel), it is important to assess the soil-specific needs for soil C sequestration and to estimate the amount which can be spared for other uses. Possible adverse impact of residue removal on soil C sequestration may be minimized by growing a winter cover crop which can compensate the loss of residue and also, in the case of legumes, enhance soil fertility. This presentation explores alternate uses of residue for soil C sequestration and biofuel production.

B51B-02 0815h INVITED

Potential for ag residue collection, economics and environmental benefits

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Removing excess corn stover and cereal straws after erosion requirements have been satisfied offers much potential as a renewable feedstock for initial biorefineries, producing fuels, chemicals and materials while reducing crop inputs, increasing farm income and offsetting greenhouse gas emissions. Two biorefinery site studies are presented for the production of fuel ethanol: SW Nebraska and Western Oklahoma. Results include excess available, delivered cost, net income to the farmer, improved SOM from move to no-till and GHG reduction from fossil fuel offset

B51B-03 0830h

Impact of Corn Residue Removal on Crop and Soil Productivity

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Over-reliance on imported fuels, increasing atmospheric levels of greenhouses and sustaining food production for a growing population are three of the most important problems facing society in the mid-term. The US Department of Energy and private enterprise are developing technology necessary to use high cellulose feedstock, such as crop residues, for ethanol production. Based on production levels, corn (Zea mays L.) residue has potential as a biofuel feedstock. Crop residues are a renewable and domestic fuel source, which can reduce the rate of fossil fuel use (both imported and domestic) and provide an additional farm commodity. Crop residues protect the soil from wind and water erosion, provide inputs to form soil organic matter (a critical component determining soil quality) and play a role in nutrient cycling. Crop residues impact radiation balance and energy fluxes and reduce evaporation. Therefore, the benefits of using crop residues as fuel, which removes crop residues from the field, must be balanced against negative environmental impacts (e.g. soil erosion), maintaining soil organic matter levels, and preserving or enhancing productivity. All ramifications of new management practices and crop uses must be explored and evaluated fully before an industry is established. There are limited numbers of long-term studies with soil and crop responses to residue removal that range from negative to negligible. The range of crop and soil responses to crop residue removal was attributed to interactions with climate, management and soil type. Within limits, corn residue can be harvested for ethanol production to provide a renewable, domestic source of energy feedstock that reduces greenhouse gases. Removal rates must vary based on regional yield, climatic conditions and cultural practices. Agronomists are challenged to develop a protocol (tool) for recommending maximum permissible removal rates that ensure sustained soil productivity.

B

B51B-04 0845h

Assessing Changes in Soil Carbon Quantity and Chemistry in Short-Rotation Hybrid Poplar Plantations

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There is increasing interest in using short-rotation woody biomass plantations as a source of fiber and as a carbon neutral energy supply. Willow, poplar, and alder are currently used in plantations in areas ranging from the Lake States to the Northwest. As with any cropping system, maintaining soil productivity through succeeding rotations is a key management goal. Where plantations are used to provide carbon sequestration benefits (i.e. bioenergy production), building and maintaining soil carbon stocks is of particular concern. We sampled three hybrid poplar farms in the Northwestern United States; all three farms are in the rain shadow of the Cascades and are on sandy soils. The farms share a similar land use history; originally sagebrush, the land was in annual crops such as peas, onions, and alfalfa, before conversion to poplar. At each farm, soil cores were taken from a field in annual crops, a first rotation poplar stand, and a second rotation poplar stand. Although results varied by farm, soil carbon concentrations were generally higher in the first and second rotation poplar stands than in the row-cropped fields; this was more pronounced in the 0-5 cm and 5-10 cm depths. There were no apparent declines in soil carbon concentration between the first and second rotations. Soil carbon concentrations under poplar were also higher than those in soils from native sagebrush, the original land cover. Analysis of the chemical composition of the carbon using pyrolysis molecular beam mass spectrometry indicates that by the second rotation, the chemical signature of the carbon resembled that found in materials taken from the poplar trees.

B51B-05 0900h INVITED

Implications of Using Corn Stalks as a Biofuel Source: A Joint ARS and DOE Project

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Corn stover is a readily source of biomass for cellulosic ethanol production, and may provide additional income for growers. Published research shows that residue removal changes the rate of soil physical, chemical, and biological processes, and in turn, crop growth. Building a sustainable cellulosic ethanol industry based on corn residue requires residue management practices that do not reduce long-term productivity. To develop such systems, impacts of stover removal on the soil and subsequent crops must be quantified. The ARS/DOE Biofuel Project is the cooperative endeavor among scientists from six western Corn Belt US Dept. of Agriculture, Agricultural Research Service (ARS) locations and US Dept. of Energy. The objectives of the project are to determine the influence of stover removal on crop productivity, soil aggregation, quality, carbon content, and seasonal energy balance, and carbon sequestration. When residue is removed soil temperatures fluctuate more and soil water evaporation is greater. Residue removal reduces the amount of soil organic carbon (SOC), but the degree of reduction is highly dependent on degree of tillage, quantity of stover removed, and frequency of stover removal. Of the three cultural factors (stover removal, tillage, and N fertilization) tillage had the greatest effect on amount of corn-derived SOC. No tillage tends to increase the fraction of aggregates in the 2.00 to 0.25 mm size range at all removal rates. Stover harvest reduces corn-derived SOC by 35% compared to retaining stover on the soil averaged over all tillage systems. Corn stover yield has not differed across stover removal treatments in these studies. In the irrigated study, grain yield increased with stover removal. In the rain-fed studies, grain yield has not differed among residue management treatments. Incorporating the biomass ethanol fermentation by-product into a soil with low SOC showed a positive relationship between the amount of lignin added and the subsequent humic acid concentration and aggregate stability. These and future outcomes from this effort will provide DOE and the developing biomass ethanol industry knowledge and guidelines on the environmental and crop productivity consequences of large-scale collection of corn stover.

B51B-06 0915h

Monitoring Soil Carbon Inputs and Changes with Crop Type and Management Practice Using Pyrolysis-Molecular Beam Mass Spectrometry

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With the increasing need to produce more renewable bioenergy products comes the need to assess the impacts of these agricultural cropping practices on soil carbon inputs and changes. In addition, the anticipated increased use of short rotation woody crops for biomass and bioenergy programs requires that we improve our understanding of the effects of management on soil quality and soil organic matter. We have developed an atmospheric pressure rapid pyrolysis technique that can analyze up to 150 samples per day with direct sampling molecular beam mass spectrometry (py-MBMS). The advantage of this technique is that complex biomaterials can be rapidly pyrolyzed and subsequent fragment condensation reduced which provides molecular data for both light and heavy pyrolysis products. Because of the chemical richness of the resultant mass spectra, we use multivariate statistical analysis techniques to provide efficient pattern recognition and identify major pyrolysis products. These products can then be used to characterize soil organic matter content and composition. Preliminary results from 0-5 cm soils cores taken from soils that were cropped with either continuous till or no till sorghum or soybeans show that we can easily distinguish between till and no till regardless of crop type. Analysis of depth increments of forest soils that experienced a chronosequence of wind disturbances showed that we could distinguish depth, location, and recent and older soil organic matter species of the soil cores with this technique. Analysis of well-characterized CRP (Conservation Reserve Program) soils again allowed us to distinguish depth and location and to accurately predict soil microbial biomass contents. We will present these results and discuss their implications for quantitatively assessing the impacts of bioenergy cropping on soil organic matter.

B51B-07 0930h

The Impact of Elevated CO2 on Soil C and N Cycling as Revealed by Decomposition of 15N-13C Labelled Residues in a Pasture Soil Exposed to FACE Conditions for 9 Years.

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The effect of prolonged elevated atmospheric CO2 on soil C and N cycling remains a widely debated topic. Elevated atmospheric CO2 may alter decomposition rates through changes in plant residue quality and through its impact on soil microbial activity. This study examines whether plant residues produced under elevated CO2 decompose differently than residues produced under ambient CO2. Moreover, a long-term experiment offered a unique opportunity to evaluate assumptions about C-cycling under elevated CO2 made in coupled climate-SOM models. Trifolium repens and Lolium perenne residues, produced under elevated and ambient CO2, at two levels of N fertilizer were incubated in soil for 90 days. Soils and residues used for the incubation had been exposed to ambient and elevated CO2 under Free Air Carbon Enrichment (FACE)-conditions and had received 15N-N-fertilizer for 9 years. The rate of decomposition of L. perenne and T. repens residues was unaffected by elevated atmospheric CO2 and rate of N fertilization; soil respiration and recovery of 15N in the soils was independent whether the residues were grown under ambient or elevated CO2. Any changes in litter C:N ratio due to elevated CO2, did not affect residue decomposition. If under prolonged elevated CO2 changes in soil microbial dynamics had occurred, it was not reflected in the rate of residue decomposition. Only respiration of L. perenne soil, following low N fertilization was enhanced after exposure to elevated CO2, irrespective of the addition of ambient or elevated residues. This increase in respiration was not reflected in an increase in the microbial biomass of the L. perenne soil. The contribution of old and newly sequestered C to soil respiration, as revealed by the 13C-CO2 signature, reflected the turnover times of SOM-C pools as described by multi-pool SOM models. The results appear not to confirm the assumption of a negative feedback induced in the C-cycle by elevated CO2 used in coupled climate-SOM models following an increase in elevated CO2. Moreover, this study showed no evidence for a positive feedback in the C-cycle following additional N fertilization.

B51B-08 0945h

Factors Influencing Changes in Soil Carbon Following Afforestation of Pastures With *Pinus radiata* in New Zealand

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Since 1992, afforestation with *Pinus radiata* D.Don in New Zealand has led to the establishment of over 500,000 ha of new plantation forests, about 85% of which are on grazed pastures. These forests accumulate carbon (C) in vegetation rapidly, storing on average about 230 Mg C ha^{-1} during a 30-year rotation. Although mineral soil C levels can decline following afforestation, the consequences of afforestation on mineral soil C pools are poorly understood. Our observations at several sites throughout New Zealand suggest that afforestation decreases soil C and N cycling rates, increases soil C:N ratios, and lowers soil temperatures. Using the G'DAY ecosystem model, we investigated the interactions between N cycling processes and soil C storage at a site where soil C content had not changed following afforestation. Our simulations, in contrast, showed an increase in soil C following afforestation, primarily as a result of increased above-ground inputs and soil C:N ratio. We concluded that G'DAY overestimated C inputs from the forest floor to the mineral soil. We then used the ROTHC soil C model to examine changes in plant C inputs at another site where mineral soil C declined with afforestation. Below-ground forest C inputs were estimated assuming a steady-state relationship between litterfall and soil respiration; these inputs increased linearly between years 6 and 12, after which they remained constant at 1.53 Mg C ha^{-1}y^{-1} until harvest at year 26. Measured changes in soil C (0-20 cm) and estimated below-ground inputs were then used to estimate above-ground inputs (as a proportion of total litterfall (3.81 Mg C ha^{-1}y^{-1})) to the mineral soil. Our results suggest that 10% of forest floor inputs entered the mineral soil over one rotation. Using these results, and estimates of slash and weed production during/after harvest, we found that mineral-soil C stocks would likely continue to decline during second and third rotations of *P. radiata*; the magnitude of this decline depended in part on slash inputs to the soil. How afforestation changes mineral-soil C could depend on previous pasture management; soil C losses could be higher when afforestation occurs on highly productive pastures. While slash inputs after harvest help minimize soil C losses, they do not compensate for the ecosystem changes in C inputs viz. primarily below-ground under pasture and above-ground under forest.

B51C MCC: Level 2 Friday 0830h

Microbe and Mineral Interactions and the Biogeochemistry of Reduced Sulfur Posters *(joint with A, H, OS, P, V)*

Presiding: **B Twining,** Environment School, Yale University**; J R Scott,** Idaho National Engineering and Environmental Laboratory

B51C-0966 0830h POSTER

Application of Flow Field Flow Fractionation-ICP-MS for the Study of Uranium Binding in Cell Suspensions of Shewanella oneidensis

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