Fe-silicates. In the lactate treatment protist concentrations increased by over an order of magnitude to 2914±1482 protists/ml before decreasing and planktonic cell concentrations increased almost two orders magnitude to $1.4\pm1.3\times10^7$ cells/ml whereas no change in protist and cell concentrations occurred in the control treatment. Increased rates of Fe(III) reduction may have occurred in the low permeability non-peat rich zones but the correlations with the physical and chemical descriptions of aquifer heterogeneity were weak, probably as a result of Fe precipitation, Fe sorption, and the abundance of Fe(III) bearing minerals and bacteria at all depths. This work has important implications for developing methods to remediate subsurface sites contaminated with metals and radionuclides.

B51A MCC: 3014 Friday 0800h

An Ecohydrological Perspective on Woody Plant Encroachment in Semiarid Regions I *(joint with H)*

Presiding: **R L Scott,** USDA Agricultural Research Service**; B P Wilcox,** Texas A&M University

B51A-01 0805h

Ecohydrology and Woody Plant Encroachment: a Conceptual Framework for Evaluating Landscape Consequences

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Increases in the abundance or density of woody plants in historically semiarid and arid grassland ecosystems have important implications for hydrology, ecology, and society. Using a simplified water-balance model, we propose a framework for conceptualizing how woody plant encroachment is likely to affect components of the water cycle within these ecosystems. In these systems, shrub removal has been proposed as mechanism for increasing watershed yield, but such increases are likely only in systems with shallow bedrock, riparian systems, or climatic systems where precipitation exceeds potential evapotranspiration for extended periods. In semiarid and arid systems abiotic controls on evaporation overwhelm biotic control of streamflow. In these systems, the predominant effects of woody plant encroachment that promote ecohydrological feedbacks are changes in: infiltration, depth of plant water removal, generation of transient overland flow and near-ground energy budgets that affect the ratio of evaporation (E) to transpiration (T). In these more xeric areas, the ratio of E:T is critical because it indicates the biological use of water which influences landscape structure. Increasing woody plant cover is associated with larger open interspaces, at the landscape scale the differential contribution of canopy versus interspaces may change landscape E:T. Alterations of spatial structure and ecohydrology likely influence other biogeochemical processes, such as carbon cycling. At the landscape scale, total respiration depends on the magnitude of canopy/interspace respiration flux scaled by the spatial extent of interspaces and canopy space. Canopy respiration is strongly correlated to T, while interspace respiration is largely driven by soil water availability and therefore is driven by factors that control E. Resolving the partitioning of E:T should help resolve the net effect of woody plant encroachment on other biogeochemical cycles at the landscape scale. This framework for considering the effects of woody plant encroachment highlights important ecological and hydrological interactions that serve as a basis for predicting other ecological aspects of vegetation change.

B51A-02 0820h INVITED

Trees, Water, Space and Time

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Woody plant proliferation in grasslands and savannas over the past century has been a globally widespread phenomenon. Rates and patterns of woody community development in arid and semi-arid grasslands are often regulated by a hydrological process mediated by soils, topography and disturbance. Once established, woody plant communities have the potential to alter hydrological processes either directly or indirectly. This presentation will focus on hydrological mediation of woody plant establishment and community development. Though not widely documented, rates, patterns and dynamics of shifts from grass to woody plant domination, appear to be strongly influenced by the amount and seasonality of rainfall, operating against a backdrop of topoedaphic heterogeneity. Disturbances may override or amplify climate/soil effects. Establishment of woody seedlings is a critical first-step in woody plant encroachment. How do seedlings gain a foothold in grasslands? How important is episodic vs. continuous recruitment? How do hydrological factors affecting woody plant recruitment differ from those affecting stand development and stand dynamics at landscape levels of resolution? To what extent are woody plant communities self-regulating and subject to hydrologically mediated density dependence? These questions will be addressed in the context of vegetation inertia and lag effects which make it difficult to assign primacy to driving forces.

B51A-03 0840h

Scale Issues in Ecohydrological Processes in Grassland-Shrubland Transitions, Jornada, NM

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Rainfall-simulation experiments have proved invaluable in developing our understanding of ecohydrological processes relating to grassland-shrubland transitions in the American Southwest and elsewhere. Grassland communities are effective at buffering the runoff and erosional response, whereas shrublands accelerate runoff and erosion rates leading to local concentrations of resources. Further feedbacks occur in terms of nutrient redistribution both dissolved in overland flow and adsorbed onto transported sediment. Field experiments at the Jornada LTER site over the last ten years have evaluated these processes on undisturbed and grazed black grama grassland, and creosotebush and mesquite shrubland communities. More recently, investigations have been carried out to evaluate the behaviour of these systems at the landscape scale. Low-cost sampling designs have been used so that relatively large spatial samples can be collected. Currently, 96 of these samplers are in operation at Jornada, evaluating water, sediment and nutrient transfers in the interrill zone. A smaller number of samplers are used to characterize rill transfers of water and dissolved nutrients. The samplers are located along ecotones so that the spatial relationship of grassland-shrubland and shrubland-shrubland transitions can be evaluated. An interesting initial result of the use of these samplers is that they provide different relative patterns of fluxes from those that would be estimated using the plot-based studies. These results contribute to the growing body of evidence that the scaling properties of landscape-degradation processes in these environments are non-linear. Further instrumentation of watersheds is being carried out in order to evaluate these non-linearities at larger scales. At the same time, intensive spatial sampling of hydrological, sedimentary and nutrient characteristics of the surfaces of the different vegetation communities is being carried out. The rationale for this sampling is to be able to generate multi-scale databases that can be used to parameterize a range of models that investigate the transition processes and process interactions. These models work at a range of levels of abstraction, albeit all with a process base. Furthermore, the spatial measurements themselves give clues to the cause of the non-linearities in scaling and the processes that may generate them. This paper concludes by looking at the relative advantages and disadvantages of the different approaches that can be used to evaluate ecohydrological interactions.

B51A-04 0855h

Spatio-temporal Variation in Soil Water in a Semiarid Woodland: Implications for Woody Plant Encroachment

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Woody plant encroachment in dryland ecosystems is an issue of global concern, yet mechanisms related to encroachment are poorly understood. Mechanisms associated with woody plant encroachment likely relate to soil water dynamics, yet few long-term data sets exist to evaluate soil water heterogeneity. Here we highlight how soil water varies both temporally (wet vs. dry years and snow vs. rain dominated months) and spatially (vertically with depth and horizontally beneath vs. between the canopies of woody plants). We measured soil water content using neutron probe over a 15-year period in a pinyon-juniper woodland at the Mesita del Buey Research Site in northern New Mexico. Our objectives included assessing (1) the temporal variability of soil water, both as a function of depth and as a function of cover (canopy patches beneath trees, intercanopy patches between trees, and edges between the two patch types); and (2) implications for the vertical and horizontal distributions of plant-available water. Our results highlight (1) large temporal variations in soil water availability, driven largely by differences in winter precipitation, and (2) the potential importance of considering horizontal as well as vertical heterogeneity in soil moisture. The spatio-temporal variation in soil water that we quantify highlights the potential complexity of changes in the water budget that could be associated with woody plant encroachment and emphasizes the importance of considering horizontal as well as vertical heterogeneity in soil water in improving our understanding of mechanisms associated with woody plant encroachment.

B51A-05 0910h INVITED

Interactions Among Water, Carbon, And Nutrient Cycles With Woody Plant Encroachment Into Grasslands

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The expansion of woody plants into deserts, grasslands, and savannas alters water and nutrient cycling, affecting some one-fifth of the world's population. In this talk, research along precipitation gradients in North and South America will be used to examine interactions among water, carbon and nutrients in the southwestern U.S. and in grasslands of Argentina and Uruguay. Those interactions include groundwater uptake, carbon sequestration, changes in salinity and pH, and new evidence for the direct uptake of nutrients at depth using stable isotopes. The talk will end with a discussion of key unanswered research questions at the boundary of hydrology, biology, and geochemistry associated with woody plant encroachment.

URL: http://www.biology.duke.edu/jackson

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 semiarid 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.

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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