soil, due to the spatial variability of infiltration, canopy shading, and soil texture effects. Therefore, nitrogen mineralization is more intense beneath shrub canopies than adjacent interspaces. In contrast, the soil moisture distribution in grassland promotes more spatially homogenous nutrient cycling. We test this model with laboratory soil incubations. These laboratory experiments demonstrate that soil moisture is the key control on N mineralization, not soil organic carbon or cover type.

H52A MCC: Hall C Friday 1330h

State-of-the-Art in Ecohydrology I Posters *(joint with B, GC)*

Presiding: **D Mackay,** University of Wisconsin**; C Luce,** USDA Forest Service

H52A-0825 1330h POSTER

Land Cover and Land Use Changes and Their Impacts on Groundwater Resources and Carbon Cycling in SW Egypt

Mohamed Sultan[1] (716 645 6800; misultan@nsm.buffalo.edu); Richard Becker[1] (716 645 6800; rhbecker@buffalo.edu); Julie D Jastrow[2] (630 252 3226; jdjastrow@anl.gov); Raymond M Miller[2] (630 252 3395; rmmiller@anl.gov); Jeonkon Kim[3] (614 292 2033; jkim@geology.ohio-state.edu); Zeinhom El Elfy[4] (012460 58 54; zinhsayd23@yahoo.com)

[1]University at Buffalo (SUNY), 876 Natural Science Complex, Buffalo, NY 14260, United States

[2]Argonne National Lab, 9700 South Cass Ave, Argonne, IL 60439, United States

[3]Ohio State University, Department of Geological Sciences 275 Mendenhall Laboratory 125 South Oval Mall, Columbus, OH 43210, United States

[4]Egyptian Geological Survey and Mining Authority, 3 Salah Salem Street Abbassiya, Cairo 00000, Egypt

The construction of the Aswan High Dam has had major impacts on the landscape and on the water and carbon reservoirs in SW Egypt. It gave rise to Lake Nasser, an extensive (capacity: 1.6 x 1011 m3, length: 500 km, average width: 12 km) reservoir. Recharge from the lake raised the groundwater table by as much as 20m; the lake and the companion agricultural development projects are creating new carbon sinks. We applied an integrated systems approach (involving remote sensing, geochemical and physical analyses, and hydrologic modeling) to assess, monitor, and model the recent and future impacts of changes in the landscape in SW Egypt. Co-registered temporal satellite images (CORONA, MSS, TM, DTED), and lake stages were used to monitor the temporal variations in the arial extent of Lake Nasser. Temporal variations were accounted for in a 2-dimensional groundwater flow model constructed for the SW corner of Lake Nasser. The model, constrained by regional-scale groundwater flow and near-lake head data, was calibrated to observed heads from 1970 to 2000. Predictive analyses for the next 50-yr period indicate a substantial reduction in recharge with time (approx. 86% reduction in 30-yr recharge). The recharge front advanced northwestward at an average rate of 0.24-0.57 km/yr (i.e., less than 20 km by 2000) consistent with inferences made from O and H isotopic data for groundwater from shallow and deep wells in the vicinity of the Lake that indicate that infiltration from the Lake was undetectable in areas that are 20 km or more from the Lake. Analysis of two suites of soil samples from fields that were reclaimed within the past 100 years indicate that organic carbon and nitrogen are being sequestered at rates ranging from 0.0282 to 0.1705 g C/kg soil/yr and from 0.003 to 0.0147 g N/kg soil/yr. The geologic and agricultural practice controls on carbon sequestration rates in soils are currently being examined and the hydrology model is being extended to incorporate the entire Lake Nasser and adjoining lakes and lands.

H52A-0826 1330h POSTER

Human Appropriation of Global Terrestrial Evapotranspiration

Shannon M Sterling[1] (919-684-5847; shannon@duke.edu)

Stuart Rojstaczer[1] (650-364-1590; stuart@duke.edu)

[1]Center for Hydrologic Science, Division of Earth & Ocean Sciences, Box 90230, Duke University, Durham, NC 27708, United States

Human alteration of the Earth's land cover is escalating. This change can significantly impact evapotranspiration in regional ecosystems, which in turn influences the global hydrologic cycle. What is the magnitude of this influence? Accurate estimates of the human impact on terrestrial evapotranspiration are lacking.

We derive two independent estimates of human appropriation of terrestrial evapotranspiration. Six spheres of human activity on the planet form the basis for our inventories: 1) conversion of land for agriculture, 2) conversion of land to urban areas, 3) conversion of land to grazing, 4) deforestation and tree farms, 5) water reservoir creation, and 6) biomass burning. We base our first estimate upon our earlier inventory of human appropriation of net primary productivity (Rojstaczer, Sterling and Moore, Science, 2001) that we convert into evapotranspiration via empirical water use efficiency data. We use independent evapotranspiration data for our second estimate. For both measures, we assemble multiple independent estimates of the key variables from the literature. We estimate the uncertainty of both measures using Monte Carlo simulations. Our results differ considerably from an earlier often-cited estimate (Postel et al., Science, 1996).

H52A-0827 1330h POSTER

Measurements of Whole Canopy Water Status Using an Impulse Time Domain Transmission Technique

Eleanor J Burke[1] (520 621 1985; eleanor@hwr.arizona.edu)

R Chawn Harlow[1] (chawn@hwr.arizona.edu)

Ty P Ferre[1] (ty@hwr.arizona.edu)

[1]Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721, United States

The volumetric water content of vegetation is an important ecohydrological variable that, at the level of individual leaves, is a direct measure of leaf water status. Measurements of water status are available at the scale of a leaf and stems but not at the scale of whole plant canopies. Microwave remote sensing and eddy correlation techniques measure the effects of canopy water status at large scale (tens of meters to tens of kilometers). This poster attempts to bridge this gap in scales by relating measurements of whole canopy dielectric permittivity to whole canopy water status on the scale of a few meters. The method used to determine whole canopy dielectric permittivity is the impulse time domain transmission technique that has recently been developed to measure the volumetric water content of soils.

H52A-0828 1330h POSTER

Fogwater Inputs to a Cloud Forest in Puerto Rico

Werner Eugster[1] (eugster@giub.unibe.ch); Reto Burkard[1] (burkard@giub.unibe.ch); Friso Holwerda[2] (luquillo@hotmail.com); Sampurno Bruijnzeel[2] (brul@geo.vu.nl); Frederick N. Scatena[3] (fns@sas.upenn.edu); Rolf Siegwolf[4] (rolf.siegwolf@psi.ch)

[1]University of Bern, Institute of Geography, Hallerstrasse 12, Bern 3012, Switzerland

[2]Vrije Universiteit Amsterdam, Faculty of Earth and Life Sciences, De Boelelaan 1085, HV Amsterdam 1081, Netherlands

[3]University of Pennsylvania, Department of Earth and Environmental Science, 240 South 33rd Street, 156 Hayden Hall, Philadelphia, PA 19104-6316, United States

[4]Paul Scherrer Institute, Stabile Isotope Research Group, Villigen 5232, Switzerland

Fog is highly persistent at upper elevations of humid tropical mountains and is an important pathway for water and nutrient inputs to mountain forest ecosystems. Measurements of fogwater fluxes were performed in the Luquillo mountains of Puerto Rico using the eddy covariance approach and a Caltech-type active strand cloudwater collector. Rainfall and throughfall were collected between 25 June–7 August 2002. Samples of fog, rain, stemflow and throughfall were analyzed for inorganic ion and stable isotope concentrations (δ^{18}O and δD). Initial results indicate that fog inputs can occur during periods without rain and last for up to several days.

The isotope ratios in rainwater and fogwater are rather similar, indicative of the proximity of the Carribbean Sea and the close interrelation between the origins of fog and rain at our experimental site. Largest differences in isotope ratios for fog were found between daytime convective and nighttime stable conditions. Throughfall was always exceeding rainfall, indicating (a) the relevance of fogwater inputs and (b) the potentially significant undersampling of rainfall due to relatively high wind speeds (5.7 m/s mean) and the exposition of our field site close to a mountain ridge.

Our size-resolved measurements of cloud droplets (40 size bins between 2 and 50 μm aerodynamic diameter) indicate that the liquid water content of fog in the Luquillo mountains is 5 times higher than previously assumed, and thus does not differ from the values reported from other mountain ranges in other climate zones. Average deposition rates are 0.88 mm and 6.5 mm per day for fog and rain, respectively.

URL: http://giub.unibe.unibe.ch/∼burkard/messkampagne_pr.html

H52A-0829 1330h POSTER

Hydrological Properties and Flow Paths Change with 4.1 Million Years of Soil Development in the Hawaiian Islands

Kathleen A Lohse[1] (650-724-1535; klohse@nature.berkeley.edu)

William E Dietrich[2] (510-642-2633; bill@seismo.berkeley.edu)

[1]University of California, Berkeley , Department of Environmental Science, Policy and Management 151 Hilgard Hall , Berkeley, CA 94720, United States

[2]University of California, Berkeley, Department of Earth and Planetary Science, Berkeley, CA 94720, United States

A well-characterized chronosequence of soils in the Hawaiian archipeligo provides an excellent opportunity to examine the effects of time on hydrological properties and flow paths in a humid tropical environment. Detailed hydrological studies were conducted at the extreme ends of a chronosequence of soils in the Hawaiian Islands as a part of a larger study evaluating hydrologic losses of nitrogen (N) under elevated N supply. Specifically, we determined in-situ soil-water retention, soil hydraulic conductivity, and flow path characteristics on a 300 year old Andisol and 4.1 million year old Oxisol both supporting native montane tropical forest. We found that surface and subsurface soils drained rapidly at the young site but observed significant differences between surface and subsurface soil-water retention and hydraulic conductivity characteristics at the old site. An artificial rainfall experiment with deuterium isotope tracer showed that water was dominantly downward advecting at the young site. At the old site, water moved fast as by-pass flow through the near-surface soils to an impeding subsurface clay layer and then moved both laterally along the clay contact and slowly downward as piston flow. Across the soil age gradient, soil anisotropy and the probability of lateral flow increased as saturated hydraulic conductivity in subsurface soils declined. Findings from this study demonstrate that soil development with time can have a profound effect on the rate and direction of water flow which have important implications for the rate and trajectory of soil and ecosystem formation, nutrient cycling and storm runoff mechanisms.

H52A-0830 1330h POSTER

Carbon, Water, and Energy Dynamics in a Savanna Mosaic: Results From an African Field Campaign

Christopher A Williams[1] (919-660-5463; caw4r@duke.edu)

John D Albertson[1] (919-660-5468; john.albertson@duke.edu)

[1]Duke University, CEE, Box 90287, Durham, NC 27708, United States

Savanna ecosystems cover a large fraction of the terrestrial landscape with a shifting mosaic of vegetation that is poorly understood. Vegetation dynamics in savannas are believed to be triggered by variation in climate forcing with potential local and regional scale feedbacks on climate and with nonlinear behavior, such as self-organization. Recent debate has brought attention to uncertainty regarding the role of savannas in global carbon and water cycles, identifying the need for data that can address the coupled water and carbon dynamics of these sensitive ecosystems. We report results from a 30-day field campaign conducted in southern Africa near Ghanzi, Botswana along the Kalahari Transect. This water-limited site is ideal for studies of soil and plant water relations because high spatial and temporal variability in rainfall has direct effects on vegetation function, extent, and composition. We characterized the functional response of tree/grass/bare soil mosaics during a prolonged drydown following a large rain event (85 mm) at the end of the 2002 wet season. Net radiation, sensible, latent and soil heat fluxes, carbon dioxide exchange, soil moisture, soil temperature, and vegetation temperatures were measured at two sites, one dominated by woody vegetation (Acacia and Terminalia) and the other composed of native grasses, shrubs, and bare soil. We characterized the vegetation structure within the footprints of both towers with measurements of leaf area, fractional vegetation cover, and

profiles of aboveground and belowground biomass. Additionally, leaf-level gas exchange measurements were conducted on dominant species. Soil moisture decayed from a peak of 0.28 after the storm to 0.05, measured 5 cm below the soil surface. The drydown resulted in a continual increase in the daytime Bowen ratio, a decrease of leaf-level evapotranspiration, and reduced net ecosystem exchange of CO2. Biophysical differences between C3 trees and C4 grasses were evident from vapor pressure deficit and temperature controls on assimilation. Allometric relationships were developed for woody vegetation relating diameter, height and canopy dimensions. Patch scale patterns of vegetation assemblages reflect multiple resource acquisition and life form strategies. The contrasting response of the woody and grass plant functional groups to the decreased soil water content is to be highlighted, with a discussion of implications for longer-term dynamics.

H52A-0831 1330h POSTER

Forcing of 1982-1997 Ecosystem Water and Carbon Fluxes in the Conterminous United States: Relative Influence of Vegetation Structure and Phenology Versus Climate

Michael A. White[1] (435-797-3794; mikew@cc.usu.edu)

Ramakrishna R. Nemani[2] (nemani@ntsg.umt.edu)

Petr Votava[2] (votava@ntsg.umt.edu)

[1]Utah State University, AWER 5210 Old Main Hill, Logan, UT 84322-5210, United States

[2]University of Montana, NTSG/School of Forestry, Missoula, MT 59812, United States

We used daily 8km 1982-1997 simulations of ecosystem hydrology and gross primary production (GPP) for the conterminous United States to test the relative influence of variability in vegetation structure and phenology versus climate. The model, the Terrestrial Observation and Prediction System (TOPS) employs: (1) gridded meteorological observations derived from station observations; (2) leaf area index (LAI) and the fraction of photosynthetically active radiation absorbed by plant canopies (FPAR) from the advanced very high resolution radiometer; (3) the daily water balance functions of the Biome-BGC model including Penman-Monteith evapotranspiration and a simple bucket model; and (4) a light use efficiency model to calculate GPP. TOPS differs from Biome-BGC in that LAI and FPAR are forced by observations and net carbon fluxes are not calculated. We conducted three simulations: actual climate and actual remote sensing; average climate and actual remote sensing; and actual climate and average remote sensing. We then assessed the forcing of ecosystem water and carbon fluxes by climate versus by the timing and magnitude of vegetation activity. Results indicated that for most of the US, climate variability was the dominant ecosystem forcing but that for specific regions or time periods, variability in remotely-sensed inputs controlled the interannual variability of fluxes.

H52A-0832 1330h POSTER

Modeling Ecosystem Respiration Over an Evolving Successional Landscape

Ryan E Emanuel[1] (434-924-1306; re4d@virginia.edu)

John D Albertson[2] (919-660-5468; john.albertson@duke.edu)

Howard E Epstein[1] (434-924-4308; hee2b@virginia.edu)

Paolo D'Odorico[1] (434-924-7241; paolo@virginia.edu)

Christopher A Williams[2] (caw4r@duke.edu)

[1]Department of Environmental Sciences, University of Virginia, Clark Hall, Charlottesville, VA 22904, United States

[2]Department of Civil and Environmental Engineering, Pratt School of Engineering, Duke University, PO Box 90287, Durham, NC 27708, United States

Successional ecosystems are believed to be significant sinks of atmospheric carbon dioxide. In order to explore the mechanisms of carbon sequestration over successional timescales, an eddy covariance system was installed above a crop field at the Blandy Experimental Farm in Virginia, USA in January 2001. Half-hourly fluxes of carbon dioxide and water vapor, and state variables including soil temperature and soil moisture were measured continuously through one season of crop growth and the period of succession following harvest of that crop. Here we report the results of the first year of successional growth in the absence of cultivation. Despite primary production on the order of 1 kgm^{-2} during the first full year of succession, this ecosystem remains a net source of carbon dioxide to the atmosphere. To investigate this phenomenon, a process-based model of ecosystem respiration was developed using nighttime eddy covariance measurements partitioned into bins based on soil moisture and vegetative structure. Within each bin, nighttime flux was evaluated as an exponential function of soil temperature. Output from the model was compared with concurrent ground-based measurements of ANPP and soil respiration. Our model implies that ecosystem respiration exceeds photosynthetic uptake in this early stage of succession, and demonstrates mechanistically the means by which carbon flux is controlled by soil moisture, soil temperature and vegetative structure at hourly to seasonal scales.

H52A-0833 1330h POSTER

Interaction Between Vegetation Length Scales and Atmospheric Properties

Nathaniel A Brunsell[1] (919-660-5468; brunsell@cc.usu.edu)

John D Albertson[1] (919-660-5468; john.albertson@duke.edu)

[1]Dept. of Civil and Environmental Engineering Duke University, Box 90287, Hudson Hall, Durham, NC 27708-0287, United States

The effect of vegetation length scale on atmospheric properties is investigated using a coupled large eddy simulation (LES)-soil vegetation atmosphere transfer (SVAT) model with remotely sensed land surface conditions. The issue of variation in vegetation scale and atmospheric boundary layer (ABL) height are examined to assess potential measures of horizontal variability that might be used to ammend Monin-Obukhov similarity theory. Using artificial model surfaces for vegetation with various length scales, the modifications to the stability functions are proposed. The new stability functions are assessed with the Monsoon '90 dataset and remotely sensed estimation of the vegetation length scales. The interaction of horizontal heterogeneity and atmospheric properties is then extended to assess feedbacks between vegetation heterogeneity and the energy fluxes of latent and sensible heat.

H52A-0834 1330h POSTER

Observations and Modelling of Carbon Dioxide flux from a Highly Nitrogen Fertilized Irish Grassland

Charlotte LE BRIS[1] (+ 353 21 490 3025; charlottelebris@hotmail.com)

Ger KIELY[1] (+ 353 21 490 2965; g.kiely@ucc.ie)

[1]Departement of Civil and Environment Engineering, University College of Cork, College road, Cork none, Ireland

Seasonal variations in the CO2 flux were observed and modelled over a grassland site in South West Ireland. The climate is temperate and humid with mean annual precipitation of about 1400 mm for the area. The grassland type can be described as moderately high quality pasture and meadow classified into the C3-grass category. Eddy covariance fluxes at 30 minutes intervals were recorded between July 2001 and July 2002. The maximum daily uptake of CO2 at the site was up to 40 g of CO2 m-2 day-1 during the growing season. The CO2 source in wintertime lasts about 15 weeks with maximum daily loss of 10 g of CO2 m-2 day-1. The annual carbon budget for that period was a carbon sequestration of about 8 T of carbon ha-1 yr-1. Different combinations of models were then applied to simulate the net ecosystem CO2 flux for the site with a 30 minutes time step over the one-year study period. Two different models were used to simulate the grass CO2 net assimilation: a biochemical model adapted from Farquhars and Ball & Berrys works and a semi-empirical physiological model adapted from Jacobs' works; two formulations for the soil respiration component; two descriptions of the leaf area index: one is binary (summer value and winter value) and the other is variable LAI based on the growth representation of plants. All formulations were found to yield consistent results with observed data.

H52A-0835 1330h POSTER

Using Remote Sensing and GIS Techniques to Identify Watersheds for Brush Control to Maximize Water Yield

Jason D Afinowicz[1] (1-979-845-7640; jason@cora.tamu.edu)

Clyde L Munster[1] (1-979-847-8793; c-munster@tamu.edu)

Bradford P Wilcox[2] (1-979-458-1899; bwilcox@tamu.edu)

Ronald E Lacey[1] (1-979-845-3967; ron-lacey@tamu.edu)

[1]Department of Biological and Agricultural Engineering - Texas AM University, 201 Scoates Hall, College Station, TX 77843, United States

[2]Department of Rangeland Ecology and Management - Texas AM University, M.S. 2126, College Station, TX 77843, United States

Shrub encroachment has drastically transformed the landscape of arid and semi-arid rangelands of the southwestern U.S. over the past century. It has been hypothesized that this replacement of natural herbaceous growth with woody species has reduced the volume of streamflow and aquifer recharge in these landscapes. Several small scale field experiments and computer-based hydrologic simulations have been conducted to support this theory. In recent years, the State of Texas has begun to subsidize brush control as a means of augmenting streamflow. However, if brush control is to be regarded as a viable option for increasing water availability in arid or semi-arid populated areas, a technique must be determined for targeting locations where brush management funding will provide the greatest addition to water yield.

The working hypothesis is that water yield from brush control will be maximized in watersheds where; 1. Precipitation is greater that 450 mm, 2. Shrub coverage is greater than 20%, 3. Soil depth measures less than 1 m, and 4. Limestone aquifers underlie the soil profile. Locations that meet the listed criteria for candidate brush control sites can be easily identified by querying a number of data sources using Geographic Information Systems (GIS). A classification scheme was developed for remotely sensed multi-spectral imagery of arid and semi-arid areas that allows for the recognition of regions meeting the required criteria for brush cover. Selection of optimum sites based on soil and climate characteristics was conducted using high resolution databases. The methods utilized throughout the entire process were designed to be easily adapted to a variety of locations.

H52A-0836 1330h POSTER

Importance and Use of Plants in Evaluating Water Flow and Contaminant Transport in Arid Environments

Brian J. Andraski[1] (1-775-887-7636; andraski@usgs.gov); Mark W. Sandstrom[2] (sandstro@usgs.gov); Robert L. Michel[3] (rlmichel@usgs.gov); John C. Radyk[3] (jradyk@usgs.gov); David A. Stonestrom[3] (dastones@usgs.gov); Michael J. Johnson[1] (johnsonm@usgs.gov); Charles J. Mayers[1] (cjmayers@usgs.gov)

[1]U.S. Geological Survey, 333 West Nye Lane, Room 203, Carson City, NV 89706, United States

[2]U.S. Geological Survey, Denver Federal Center, P.O. Box 25046, Lakewood, CO 80225, United States

[3]U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025, United States

Improved understanding of soil-plant-atmosphere interactions is critical to water-resource and waste management decisions. Multiple-year field studies of soil-water movement at the Amargosa Desert Research Site (ADRS; http://nevada.usgs.gov/adrs/) near Beatty, Nevada identified plants as the primary control on the near-surface water balance and showed that the boundary conditions imposed by plant activity in the uppermost soil layer results in episodic, deep drying well below the root zone during periods of below-average precipitation. The results help to explain the evidence for negligible recharge and upward flow that has been inferred from environmental-tracer and soil-physics based studies of undisturbed, arid sites. The findings have contributed to the development of new conceptual models that incorporate the influence of desert vegetation in analyses of paleo- to present-day water fluxes in deep unsaturated zones.

Studies at the ADRS are also using plants to investigate the transport of contaminants away from a closed low-level radioactive waste disposal area. Soil-gas sampling results indicated that tritium has moved as much as 300 m from the disposal area, and that transport primarily occurs in the gas phase with preferential transport through coarse-textured sediment layers. The need for an efficient means of gathering plume-scale data led to the development of a method that uses plant water to identify the presence and distribution of tritium. The method entails field sampling and solar distillation of foliage to collect plant water, followed by laboratory filtration and adsorption of scintillation-interfering constituents on a graphite-based, solid-phase-extraction (SPE) column. The method was evaluated using an evergreen shrub (creosote bush; *Larrea tridentata* (DC.) Cov.). Tritium concentrations in plant water determined with the distillation-SPE method did not differ significantly

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from those determined with the standard (and more laborious) toluene-extraction method or from concentrations in soil-water vapor collected using gas-sampling methods. Thus, the solar distillation-SPE method provides a simple, cost-effective, and accurate alternative approach to identify areas of plant and soil contamination. Although work to date has focused on one plant, the approach may be transferable to other species and environments. Work at the ADRS has confirmed the importance of vegetation in arid-site hydrodynamics. Future studies will attempt to better quantify and understand the flux of tritium from the subsurface to the atmosphere through a combination of soil, plant, and evapotranspiration measurements.

URL: http://nevada.usgs.gov/adrs/

H52A-0837 1330h POSTER

Application of Swat (Soil and Water Assessment Tool) to Four Nested Grassland Catchments

Fidelma Mary Horgan[1] (+353-21-4903025; horganfidelma@hotmail.com)

Ger Kiely (+353-21-4903025; g.kiely@ucc.ie)

[1]Department of Civil Environmental Engineering, University College Cork, Ireland, Cork none, Ireland

The process of monitoring and modelling the physical and chemical dynamics of stream catchments has become a major issue of priority with hydrologists worldwide over the past few years. There is now a growing concern for the decline in stream water quality as a result of excess phosphorus concentrations and consequently much emphasis is presently being placed on the implementation of models to trace and predict the paths of surface and subsurface flow which assist in agri-chemical transport. One such model is SWAT (the soil and water assessment tool) (Arnold et al., 1998) which was developed to allow continuous-time simulations with a high level of spatial detail by permitting the division of a catchment area into grid cells. The primary objective of this particular study was to apply and test the latest version of SWAT (version 2000) to estimate flow, and phosphorus loadings for the Dripsey Catchment stream network. Similar studies carried out in the past have generally been implemented on large river basins. The area of interest concerned in this case however is much smaller consisting of four nested grassland catchments (15ha, 25ha, 2km2 and 15km2). Field instrumentation includes flow and water quality monitoring stations (i.e.both discrete and composite samples) at four sites in addition to a meteorological station located in the most upland site (15ha) for measuring rainfall, temperature, wind speed, radiation and soil moisture. The Nash-Sutcliffe coefficient for model validation revealed that the predicted average daily flow and phosphorus loading fell reasonably well within the range of measured values.

H52A-0838 1330h POSTER

Soil Moisture and Stream-Flow Modelling of an Intensively Grazed Grassland Including a Phosphsorus Module With a 30 Minutes Time Increment

Yan LACAZE[1] (yanlacaze@hotmail.com)

Gerard Kiely[1] (g.kiely@ucc.ie)

[1]Dept. of Civil and Environmental Engineering, University College Cork, College road, Cork none, Ireland

A new parameterization of soil vegetation atmosphere transfers is described. The scheme uses a three-soil layer configuration to simulate the soil moisture, as it was found to give a more robust response compared to a two-layer soil scheme. The hydrological processes leading to the stream-flow simulation are based on the response of the soil moisture model. It consists of a ponding water storage which creates surface runoff. The moisture state of soil dictates a subsurface runoff, and a third component adds base-flow. The short time step made the calibration difficult but the results reflect the quick variability of the site (a gently sloping small grassland catchment, near Cork, Ireland).

A simple phosphorus module was then combined to the existing model in order to simulate a phosphorus budget from soil to water, thus reproducing the impact of the management of the site on the stream water quality. To process this balance, three phosphorus pools are used. The most active one is the soil solution which is split between the first two soil layers. A second reservoir contains Morgans P, and a third large storage contains a slowly reactive phosphorus. These pools interact by different transfers. A slow transformation occurs between the storage zone and the Morgans P reservoir. The transfer between the soil solution and the Morgans P follows an equilibrium law. The remaining transformation considered was between the surface layer and the root zone for the soil solution. As for phosphorus uptake by plants from the root zone, this extraction is controlled by the seasonal activity of plants and the concentration of phosphorus. The discharge in the stream is simulated by two components draining the soil solution : one from the simulated surface runoff and the other from the simulated subsurface runoff. Both are controlled by the flow intensity and the phosphorus concentration. The quantity of fertiliser spread on the field is also an input for the model.

Good simulations with a short time increment are more difficult to obtain, but once calibrated and validated, the model gives a more accurate representation of the site and still provides satisfactory results when increasing the time-step, whereas it is not true for the opposite process. The model is useful in predicting the P loss to the stream.

H52A-0839 1330h POSTER

Tritium Exposure Reconstruction Using Tree Rings at Lawrence Berkeley National Laboratory

Adam H. Love[1] (510.845.9790; adamhlove@yahoo.com)

James R. Hunt[1] (510.642.0948; hunt@ce.berkeley.edu)

John P. Knezovich[2] (925.422.9670; knezovich1@llnl.gov)

[1]Civil and Environmental Engineering, University of Calfornia at Berkeley, Berkeley, CA 94720, United States

[2]Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory L-397, Livermore, CA 94551, United States

There are numerous instances where historical exposures to contaminants can determine future health impacts, but limited means exist to reconstruct those exposures from current measurements and models. The National Tritium Labeling Facility at Lawrence Berkeley National Laboratory (LBNL) has released tritiated water into the atmosphere through an adjacent stack since 1969. Some members of the surrounding community are concerned about potential health effects from the emissions and have questioned the accuracy and thoroughness of reported historical release quantities and environmental monitoring. A grove of Eucalyptus globulus surround the emission stack and were used to reconstruct historical exposure levels. Previous studies have demonstrated that plants can be reliably used as passive monitors for tritiated water, as well as many other contaminants. Because trees can sequester tritium into wood during photosynthesis, a tree provides a temporal variation of exposure at least on an annual basis. Milligram-sized samples of wood from cores were measured for carbon-14 and tritium using accelerator mass spectrometry. The carbon-14 measurements were matched with bomb curve levels of carbon-14 to independently assess the age of the wood used for organically bound tritium measurements. The tritium exposure reconstruction was consistent with annual exposure monitoring and release quantities reported by LBNL over the last 30 years. Because this location has an episodic release pattern and complex topographic and meteorological variation, the historical assessment from these environmental measurements is likely to have less uncertainty than mathematical modeling efforts.

H52A-0840 1330h POSTER

Behavior of Boron and Boron Isotopes During Uptake by *Atriplex canescens*: Desert Plants as Samplers of Boron from Soils and Groundwater

James M. Leenhouts[1] (1-520-327-4259; jiml@hwr.arizon.edu)

Randy L. Bassett[1,2] (rlbassett@worldnet.att.net)

Thomas Maddock[1] (maddock@hwr.arizona.edu)

[1]Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721, United States

[2]Geochemical Technologies Corp., 3760 Vance St, Suite 200, Wheat Ridge, CO 80033, United States

This research was conducted to determine if B isotope ratios ($^{11}B/^{10}B$) in plant tissue provide an isotopic "fingerprint" of imbibed groundwater and soil moisture. In essence, this work sought to ascertain whether plants can function as in situ samplers for B as an environmental isotope. Because very little is known about the transport and isotopic fractionation of B in plants, this study was designed to reveal any isotopic fractionation that might occur during root uptake and vascular transport by a specific arid-adapted species.

The relation between the B isotope ratios sequestered in the leaves of *Atriplex canescens* and the growth conditions of the plant were investigated using a semihydroponic greenhouse experiment. Nutrient B concentration and solution pH were selected as experimental variables as these parameters span large ranges in nature. In addition, the transition of plant-available B species from neutrally charged to anionic as a function of pH provides a mechanism through which pH-dependent B isotope fractionation may occur. The experimental setup was a randomized factorial block design in which the plants were provided six different nutrient solutions with pH values that ranged from 7.5 to 9.5 and B concentrations that ranged from 0.1 mg/L to 10.0 mg/L.

Boron concentration in the plant's leaf and stem samples followed expected patterns, with the highest B amount in the leaves of the plants fed the nutrient solution with 10.0 mg/L B. The stem samples of plants fed 0.1 mg/L B contained the least B. The ratio of B in plants fed 10.0 mg/L vs. 0.1 mg/L B was far less than the 100:1 ratio of B in the nutrients, which implies that a component of uptake is actively controlled by the plant.

Negative thermal ionization mass spectrometry was used to analyze the minute amounts of B extracted from the plant tissue digests. Statistical tests indicated that no significant isotopic fractionation occurred during uptake at any treatment pH level. The results indicate that the species *Atriplex canescens* can provide samples of B isotopes that closely represent the isotopic signature of the plant's water source.

H52A-0841 1330h POSTER

Geophysical Evidence for Lithologic and Hydrogeological Controls on Vegetation Communities in a Large Northern Peatland

Lee D Slater[1] (973-353-5846; LSlater@andromeda.rutgers.edu)

Andrew Reeve[2] (207-581-2353; asreeve@maine.edu)

Isaiah J Utne[3] (816-235-1334; jiu87d@umkc.edu)

Xavier Comas[1] (973-353-5100; xcomasca@yahoo.es)

Craig A Ulrich[1] (973-353-5100; craigulrich@yahoo.com)

[1]Dept. of Earth/Env. Sci., Rutgers University, 195 University Ave, Newark, NJ 07102, United States

[2]Dept. of Geological Sciences, U. Maine, 5790 Bryand Global Sciences Center, Orono, ME 04469, United States

[3]Dept. of Geosciences, University of Missouri - Kansas City, 5110 Rockhill Rd., Kansas City, MO 64110, United States

Recent conceptual models invoke hydrogeologic processes as a controlling factor in the development of the striking vegetation patterns observed in northern peatlands. These processes regulate the supply of solutes to the peat surface, controlling the surface-water chemistry and the supply of nutrients to plants. Geophysical studies in Caribou Bog, a 2200-hectare peatland in central Maine, indicate a close correlation between lithology of the underlying mineral soil and dominant vegetation. Electrical resistivity imaging along a 1 km transect across the central unit of Caribou Bog resolves underlying glaciomarine clay thickness. Ground penetrating radar precisely defines the glaciomarine interface where peat thickness is less than 10 m. Direct verification of peatland thickness and sampling at the mineral soil contact constrains the geophysical interpretation. Wooded heath interspersed with sphagnum/leatherleaf lawn occurs where glaciomarine clay accumulation is thickest (estimated to exceed 10 m in parts). Abrupt thinning of the glaciomarine clay, such that peat rests directly on bedrock in parts, correlates with a sharp transition to shrub heath dominated vegetation. The location of open pools within the wooded heath of Caribou Bog coincides with localized thinning of the glaciomarine clay and exposure of bedrock at the base of the bog. Groundwater flow cells recorded over two years suggest that the glaciomarine clay acts as a confining layer and impacts nutrient supply from the mineral soil, and hence vegetation patterns, at the bog surface.

H52A-0842 1330h POSTER

Assessing Essential Fish Habitat in Freshwater Environments Using Otolith Chemistry: Spring River, AR.

Nate A Bickford[1] (870-972-3086; nbickford@astate.edu)

Brad Hamilton[1] (870-972-3086)

Robyn E Hannigan[1] (870-972-3087; hannigan@astate.edu)

[1]Arkansas State University, P.O. Box 847, State University, AR 72467, United States

The identification of essential fish habitat within freshwater systems is critical to the management of the game fish populations. In order to accurately assess

habitat we investigated the physical and chemical hydrological controls on game fish abundances and distributions with the 92-km reach of the Spring River of Arkansas. The hydrology of the river was integrated in to the chemical analyses of otolith chemistry of game fish from habitats throughout the river.

Identified spatial and temporal variations in metal concentration within the Spring River are an important factor in the recognition of essential fish habitat. In the Spring River, where spatial and temporal metal concentration variations are significant, otolith chemistry has the potential to serve as a marker of essential habitat in much the same way as in estuarine and marine settings. Using otolith chemistry to identify essential habitat in freshwater systems has the potential to revolutionize ecological management strategies.

Fish otolith chemistry shows both inter-species variations and spatial variations. Spatial variations in the otolith chemistry as recorded over the life of the fish allow identification of the nursery habitat and feeding range of game fish. Using otolith chemistry, particularly variations in trace element composition rather than the traditional major element ratios (i.e., Mg/Ca), we are able to identify essential habitats and provide managers data needed for conservation and preservation of these habitats.

URL: http://www.cas.astate.edu/geochemistry/

H52A-0843 1330h POSTER

Thermal Processes and Temperature Patterns in a Complex Headwater Stream Within a Clear Cut

R.D. (Dan) Moore[1] (604-822-3538; rdmoore@geog.ubc.ca)

Peter Sutherland[2] (kant_76@yahoo.com)

[1]Departments of Geography and Forest Resources Management, 1984 West Mall, Vancouver, BC V6T 1Z2, Canada

[2]Department of Geography, 1984 West Mall, Vancouver, BC V6T 1Z2, Canada

Stream temperature is an ecologically critical variable, and stream temperature changes associated with forest harvesting are an ongoing concern in many regions. Little research has examined the energetic processes controlling headwater stream temperatures and their response to forestry operations. The objective of this study was to quantify these processes at the scales of a 220-m reach within a clear cut, and an individual step-pool unit located within the reach. At the step-pool unit, energy exchanges across the air-water surface were determined from measurements of net radiation, air temperature and humidity and wind speed, directly over the stream. Bed heat conduction was calculated from bed temperature gradients and assumed thermal conductivities. Hyporheic exchange associated with flow through the sediment upstream of the step structures was estimated from bed infiltration computed via Darcys law and hydraulic gradients determined from piezometers installed in the stream bed, coupled with temperatures of infiltrating/exfiltrating water. These observations, along with measurements of channel characteristics and streamflow, were used as input to a Lagrangian energy-balance model to simulate reach-scale stream temperature variations. At both scales, hyporheic exchange appears to exert a strong control on the energy balance and resulting stream temperatures. In particular, hyporheic exchange appeared to reduce maximum daily stream temperatures during a period of low flow and sunny weather by several degrees C, compared to simulations without hyporheic exchange.

H52A-0844 1330h POSTER

Scale of Severe Channel Disturbances Relative to the Structure of Fish Populations

Charles H. Luce[1] (208-373-4382; cluce@fs.fed.us)

Bruce E. Rieman[1] (208-373-4386; brieman@fs.fed.us)

John G. King[1] (208-373-4384; jgking@fs.fed.us)

Jason B. Dunham[1] (208-373-4380; jbdunham@fs.fed.us)

[1]USDA Forest Service, Rocky Mountain Research Station, 316 E. Myrtle St., Boise, ID 83702, United States

Stream temperature and channel disturbance are two potentially important controls on the distribution and persistence of fish populations. Temperature regulates primary physiological processes that constrain the demographic response of populations to their environments. Ultimately temperature may be a first order determinant of the patterns of potential habitat and occurrence for many species. Stream temperature can be estimated from locally derived empirical relationships with elevation or based on detailed energy balances and thus used to model the distribution of potential habitats for fishes across whole landscapes. The role of disturbance is more hypothetical. Metapopulation theory proposes that environmental variation may have an important influence on the dynamics of populations. Disturbances may depress or even eliminate local populations, but a regional population may persist because other populations are not affected. Demographic support or recolonization may occur through dispersal among populations. Clearly the scale of disturbance and population structure can be important. If the characteristic size of disturbances is larger than the extent of a local population, then adjacent populations may decline simultaneously and metapopulation structure will offer little benefit. Conversely, if the characteristic size is smaller the benefit of structure could be important. In this paper we examine the spatial scale of large disturbances in the Boise River catchment over the last 50 years. We compare that to the scale of habitat patches for bull trout defined by stream temperature and the patterns of genetic variation detected by molecular techniques. Implications for species conservation are discussed in the context of climate change (influencing habitat patch size) and fire and fuels management (influencing the scale of disturbance).

URL: http://www.fs.fed.us/rm/boise/

H52A-0845 1330h POSTER

Scour, Fill, and Salmon Spawning in a Northern California Coastal Stream

Paul Bigelow ((530) 926-1046; paulbigelow@siskiyou.net)

Earth Systems Institute, 310 N Mt Shasta Blvd, Suite 6, Mt Shasta, CA 96067, United States

Streambed scour and fill affecting incubation survival of embryos of coho (Oncorhynchus kisutch) and chinook (Oncorhynchus tshawytscha) salmon were investigated in a Northern California coastal stream (Freshwater Creek). Objectives of the study were to: (1) test a reach-scale scour and fill model (Haschenburger 1999) based on Shields stress (dimensionless shear stress), and (2) test two published hypotheses of salmon spawning adaptation to streambed scour. Testing of the model clarified some limitations, revealed potential improvements, and demonstrated accuracy in predicting scour but not fill at salmon spawning areas (redds). The model appears best suited for individual floods on reaches that are straight, in equilibrium between sediment supply and transport, and have roughness elements similar to the creek where the model was developed. Differences in model predictions and measured values were likely due to variable scour and fill patterns in Freshwater Creek that were highly influenced by sediment supply, proximity to tributary junctions and location within the channel network, and channel morphology (form roughness).

This study provided no evidence of salmon adaptation to streambed scour from: (1) reduced bed mobility as a result of surface coarsening from redd construction, or (2) selection of stable sites for spawning. Scour was often deeper at redds ($n = 16$) than the adjacent bed, although not significantly ($p = 0.16$), indicating that redd construction did not reduce scour but instead may have increased scour by loosening the bed. Scour at random locations and redd sites ($n = 9$) within a reach were similar ($p = 0.75$), indicating that scour was not a factor in spawning site selection. Testing of both hypotheses is based on small sample sizes and further testing with larger sample sizes is needed. Redd sites were commonly located upstream of log jams and consistently aggraded. Consequently, fill (rather than scour) in Freshwater Creek may have been a more significant source of mortality in redds.

H52A-0846 1330h POSTER

Numerical Modeling of the co-Evolution of Alluvial Rivers and Vegetated Floodplains

Nicholas E Allmendinger[1] (302-831-6602; nicholas@udel.edu)

James E Pizzuto[1] (302-831-2710; pizzuto@udel.edu)

[1]University of Delaware, Department of Geology 104 Penny Hall, Newark, DE 19716, United States

We are developing a model to simulate the evolution of alluvial rivers and their adjacent, vegetated floodplains. Our model consists of simplified 2-d vertically averaged equations of momentum and continuity, with depth and unit discharge as the dependent variables. Advection and diffusion terms have been omitted, leaving only gravitational acceleration, friction, and time dependent terms. The hydrodynamics model is thus a 2-d wave equation that can represent floodplain inundation in its simplest form. The effect of vegetation on the flow is represented using a spatially variable friction factor that includes momentum losses caused by the vegetation itself. The effect of vegetation can vary with time to represent growth and decay of riparian plants. Bedload and suspended sediment transport are represented by simplified semi-empirical transport equations. Suspended sediment includes both wash load and suspended bed material load. Wash load is only deposited when fluid stresses are less than a critical value. The effects of lateral slopes on bedload transport are also included. Vegetation effects transport directly by increasing critical shear stresses for erosion. Even though the hydrodynamic model does not include lateral shear, steeply sloping banks are included in the computation of friction terms. If friction on the banks exceeds threshold stresses required for erosion, bank erosion can occur.

H52A-0847 1330h POSTER

Feedbacks Between Flow, Sedimentation, and Standing Biomass on Salt-Marsh Platforms

Simon M. Mudd[1] (850-644-8488; mudd@cespr.fsu.edu)

David J. Furbish[1] (furbish@fsu.edu)

[1]Department of Geological Sciences and Center for Earth Surface Processes Research (CESPR), Florida State University, Tallahassee, FL 32306-4100, United States

Tidally induced flood-and-ebb flows over salt-marsh platforms are modeled using a nonlinear diffusion-like equation obtained from depth-integration of continuity and momentum equations for low Reynolds number flows. The diffusivity coefficient varies locally as a function of the standing biomass on the platform due to the drag of plant stems. Sedimentation on the platform is due to particle settling and trapping by plants, and thus feedbacks exist between flow, suspended-sediment transport, sedimentation, and the standing biomass of the macrophytes (i.e. Spartina alterniflora) living on the marsh. Standing biomass is a function of the time-averaged water depth above the platform, which varies spatially, and the time of year due to seasonal growing cycles. Plant stem density is a function of standing biomass, which can be calculated using measured self-thinning curves for crowded marsh ecosystems. The stem density, in turn, affects the tidal flow through variations in drag as the flood and ebb waters make their way through the macrophyte communities. Simulations suggest that, on short timescales (annual to decadal) the elevation of the marsh surface is the dominant factor in determining average depth of flow on the salt marsh in comparison to flow impedance effects associated with variations in drag (and therefore the diffusivity) due to the plant stems. Therefore the spatial pattern of plant density on the platform surface is more sensitive to the platform elevation (including its slope) than to the details of how the flow dynamics vary with biomass. Small spatial variations in flow due to spatial variations in biomass do affect the residence time of water on the salt marsh, however, and at longer timescales the spatial variation in sedimentation due to these subtle flow effects becomes important.

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H52A-0848 1330h POSTER

Effect of Burrowing Mammals on the Hydrology of a Drained Riparian Ecosystem

James Cassidy[1] (541-737-5739; James.Cassidy@orst.edu)

Maria Ines Dragila[1] (541-737-5739; Maria.Dragila@orst.edu)

[1]Oregon State University, Department of Crop and Soil Science, Corvallis, OR 97331, United States

Agricultural pollutants and excess nutrients are transported by surface and subsurface fluvial mechanisms. Diffusive transport provides significant breakdown and processing of excess nutrients before reaching water resources and ecologically sensitive habitats. However, some quantity of contaminants will bypass the system.

This study quantifies the effect of burrowing fossorial mammals, specifically voles (Microtini), on the hydrology of a drained riparian agricultural ecosystem. Animal burrows, surface features and tunnel structures are found to play a significant role in nutrient transport, which is currently unaccounted for by land managers. Furthermore, the proximity of features created by microtini rodents to agricultural tile drainage systems commonly associated with bottomland perennial agriculture may have important implications for land management of water quality. The presence of these features may require an adjustment in our understanding of drainage network behavior.