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Constructed and natural wetlands can accumulate elevated levels of selenium (Se); however, few data are available on cost-effective methods for remobilization and removal of Se from these areas. The experiment was conducted at Stewart Lake Waterfowl Management Area (SLWMA), a Se-contaminated wetland in northeastern Utah. The purpose of the experiment was to assess the effectiveness of flooding on the removal of Se from surface sediments and transport to the chemically reducing ground water 1.8 meters (m) below land surface. The 84-$m^2$ flood-experiment plot contained 10 monitoring wells, a water-quality minimonitor (continuous measurement of pH, specific conductance, water temperature, and dissolved oxygen), a down-hole bromide (Br) electrode, and 2 pressure transducers. Flooding was initiated on August 27, 2002, and a Br tracer was added to water delivered through a pipeline to the flood plot. Standing water depth in the flood plot was maintained at 0.3 m through September 1, 2002. Mean vertical water velocities were estimated to range from 0.3 to 1.3 centimeters per hour. Dissolved (less than 0.45 micron) Se increased from pre-flood concentrations of less than 10 micrograms per liter (ug/L) to greater than 800 ug/L during flooding in samples from deep (1.8 m below land surface) ground water. Se concentrations exceeded 5,500 ug/L in samples from shallow (0.8 m below land surface) ground water. Ratios of Se to Br in water samples indicate that Se moved conservatively during the experiment and was derived from leaching of near-surface sediments. Cumulative Se flux to the deep ground water during the experiment ranged from 54.9 to 172 milligrams per square meter ($mg/m^2$). Pre- and post-flood surface soil sampling indicated a mean Se flux of 750 $mg/m^2$ through the top 15 centimeters of soil. Measurable Se flux to the deep ground water would have increased if the flood experiment had continued beyond September 1, 2002. Water samples from the deep ground water collected in April 2003 (8 months after the flood experiment) contained Se concentrations of less than 20 ug/L and dissolved oxygen concentrations of less than 0.1 milligrams per liter. The minimonitor data indicate a rapid return to chemically reducing conditions in the deep ground water, limiting the mobility of the selenium dissolved in the water pulse introduced during the flood experiment. Ratios of Se to Br in deep ground-water samples collected 8 months after the experiment confirmed the removal of Se from the aqueous phase. Based on the median Se flux rate observed during the experiment of 0.65 $mg/hr/m^2$ (n = 52), seven flooding cycles would be required to meet the 4 milligrams per kilogram remediation goal in surface soils from the SLWMA wetland.

### H32D-07 1525h

## Attenuation of Nitrate-15N by Vegetated Buffers in an Irrigated Pasture System

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Irrigated pastures are found within watersheds providing much of Western North America's surface drinking water supply. Vegetative buffers are often proposed to attenuate nutrient pollutants in runoff, but there is limited information on the mechanistic functioning of buffers adjacent to irrigated pastures. This study is intended to fill this gap in knowledge by examining specific vegetation, soil, and landscape characteristics controlling buffer efficiency and capacity. At the University of California Sierra Foothill Research and Extension Center, established flood-irrigated plots with three different buffer treatments are being used to characterize the attenuation of N, P, and sediment by buffers. Stable 15N isotope tracer was applied to quantify the fate of nitrate moving through the pasture and buffers. In the first 10 days following application of the 15N tracer, 2% of the tracer was lost as runoff, with more than half of the total loss occurring from plots with no buffers. Of the remaining tracer, 47% was taken up by grass in the zone of application, 3% was taken up by vegetation within the buffers (primarily in the first 4m of buffer), 20% was stored in the A horizon of the soil, and 28% was lost via leaching and/or gaseous losses. Results presented will include the effect of buffer length on nitrient attenuation and the relative importance of different N pools for nitrate retention. This research will allow land managers to maximize efficiency of riparian buffers adjacent to irrigated pasture, potentially increasing the adoption of vegetated buffers as a management tool.

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# H32E MCC: 3020 Wednesday 1340h

## Ecohydrological and Geochemical Processes at the Hillslope and Watershed Scales I *(joint with B)*

***Presiding:*** **B D Newman,** Los Alamos National Laboratory**; D Mackay,** State University of New York at Buffalo

### H32E-01 1345h INVITED

## Vegetation, Hydrology and Biogeochemical Cycling: An Integrated View of Controls, Linkages and Feedbacks

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Many current environmental challenges (e.g., diminished water quality and supply, desertified ecosystems, climate change impacts) require an interdisciplinary understanding of the coupled behavior of vegetation, hydrology, and biogeochemical cycling. Perhaps nowhere is such interdisciplinary insight more important than in the water-limited arid and semi-arid regions of the Earth. Vegetation plays a key role in hydrological processes in these systems, affecting the evaporation, transpiration, runoff, and recharge components of the water balance. Similarly, hydrological processes are a major determinant of many ecosystem processes, including seed germination, primary productivity, the distribution of vegetation, and biogeochemical cycling of carbon, nitrogen, and other nutrients. Using examples from the Mojave, Sonoran and Chihuahuan deserts of North America, this lecture will examine the interrelated roles of vegetation, hydrological cycles and biogeochemical cycles, ranging from patch to watershed scales. Key components, nonlinearities and linkages will be identified, including critical gaps in our understanding and new approaches and methods needed to advance our current ability to characterize and model complex environmental systems. These issues will be addressed in the context of both theoretical and field-based research.

### H32E-02 1415h

## Interannual Variation in Stand Transpiration is Dependent Upon Tree Species

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In order to successfully predict transpirational water fluxes from forested watersheds, interannual variability in transpiration must be quantified and understood. In a heterogeneous forested landscape in northern Wisconsin, we quantified stand transpiration across four forest cover types representing more than 80 percent of the land area in order to 1) quantify differences in stand transpiration and leaf area over two years and 2) determine the mechanisms governing the changes in transpiration over two years. We measured sap flux in eight trees of each tree species in the four cover types. We found that in northern hardwoods, the leaf area of sugar maple increased between the two measurement years with transpiration per unit ground area increasing even more than could be explained by leaf area. In an aspen stand, tent caterpillars completely defoliated the stand for approximately a month until a new set of leaves flushed out. The new set of leaves resulted in a lower leaf area but the same transpiration per unit leaf area indicating there was no physiological compensation for the lower leaf area. At the same time, balsam fir growing underneath the aspen increased their transpiration rate in response to greater light penetration through the dominant aspen canopy Red pine had a thirty percent change in leaf area within a growing season due to multiple cohorts of leaves and transpiration followed this leaf area dynamic. In a forested wetland, white cedar transpiration was proportional to surface water depth between the two years. Despite the specific tree species' effects on stand transpiration, all species displayed a minimum water potential regulation resulting in a saturating response of transpiration to vapor pressure deficit that did not vary across the two years. This physiological set point will allow future water flux models to explain mechanistically interannual variability in transpiration of this and similar forests.

### H32E-03 1430h

## The Influence Of Water Tracks And Hillslope Position On The Physiology Of The Dominant Plant Species In The Imnavait Creek Watershed, Alaska

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Within a small arctic tundra watershed located on the north slope of Alaska, we asked if plant abundance and physiological performance are linked to hillslope position by the hydrologic processes controlling nutrient availability. Our prediction was that down slope sites and within water track sites should have the greatest nutrient availability resulting in the highest photosynthetic capacity and productivity. To examine these relationships, two transects were established in the Imnavait Creek watershed, running from the northern ridge crest to a beaded stream. In total, 16 sites, one water track (WT) and one non water track (NWT), from 8 locations, each 100 m apart were examined. At each site, soil moisture, thaw depth, canopy water status (from spectral reflectance) and species diversity were recorded. Chlorophyll fluorescence was used assess the maximum capacity of each species to transport electrons within the photosynthetic membranes of individual leaves ($ETR_{MAX}$), a variable we expect to reflect both leaf N and general photosynthetic capacity. Significant differences were found within and among the major functional groups of plants growing in the watershed. In the two deciduous shrubs, *Betula nana* and *Salix pulchra*, $ETR_{MAX}$ generally decreased down slope but no significant difference were found between the WT and NWT sites. By contrast, $ETR_{MAX}$ in *Rubus chamaemors*, also a deciduous species, showed an initial decrease at the first two locations, but then remained constant further down slope and between WT and NWT sites. In the evergreen plants, *Ledum palustre* differed in that the maximum $ETR_{MAX}$ was found at the mid-slope locations while *Vaccinium vitis-idaea* had a characteristic decrease in $ETR_{MAX}$ down slope, with a large difference between WT and NWT at the first location. The forb *Petasites frigidus* displayed a unique pattern, with large difference in $ETR_{MAX}$ between WT and NWT at sites 4 and 5, the last two locations at which this species could be found. Finally, the only graminoid species studied, *Eriophorum vaginatu*, $ETR_{MAX}$ decrease down slope in a linear fashion and had the highest absolute $ETR_{MAX}$. Additionally leaf gas-exchange was measured in *Salix pulchra* and leaf N and canopy reflectance was measured at each site. Together, our results demonstrate that while hillsope position has a significant effect on the physiology, growth and diversity of species, the relationships were not as hypothesized. Clearly other ecological, morphological or environmental factors are contributing to the productivity of the watershed and ultimately impacting the biogeochemistry of this important ecosystem.

### H32E-04 1445h

## Quantifying the Role of Cloud Water in the Hydrology of Two Montane Forest Sites on East Maui, Hawaii

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East Maui (Haleakala volcano) rises 3054 m above the ocean, and clouds intercepting the mountain slopes are an integral part of the climate. To what extent do the trees and shrubs on the mountainsides extract cloud water that contributes to soil moisture, groundwater recharge, and stream flow in the watersheds? Two sites, on the windward and leeward sides of the mountain, were instrumented to study this process. Weather stations at each site measured climate parameters, and stable isotopes of fog, rain, soil water, stream flow and tree sap were measured monthly to track the proportion of cloud water in the forest hydrologic system. When clouds envelop a forest, the precipitation ranges from light mist to rain, leading to difficulties in measuring cloud water as opposed to rainfall. Deposition of cloud water depends on wind speed, droplet size, surface area of the vegetation, and many other factors. Cloud water deposition was measured on a continual basis using a vertical screen collector, which did not exclude rainfall. The fog isotope collectors did exclude vertically falling rain, and cumulative monthly fog volumes were compared with volumes from isotope rain collectors. Throughfall collectors provided information on the efficiency of the vegetation in collecting cloud water (fog drip). At the windward site, fog screen/ rain gage volume ratios normalized to collection area ranged from 0.74-4.9, with a median value of 1.5. The median fog/ rain ratio from the isotope collectors (normalized to surface area) was 0.35. The screen collector cannot be directly extrapolated to forest canopy, but the data suggest substantial impaction of cloud water on vegetation surfaces exposed to the wind. Isotopic composition of stream water reflected recent precipitation, including cloud water, while the soil water had a larger proportion of precipitation from large rainstorms. *Metrosideros polymorpha* tree sap isotopic composition was sometimes identical to fog drip, almost never similar to soil water, and generally appeared to be a mixture of fog drip and rainfall. The leeward site was deforested in the early part of the 20th century, and has remnants of cloud forest. Most water input is from infrequent large storm systems, while the clouds that envelop the site on a more frequent basis have relatively low water content. Fog screen/ rain gage volume ratios here ranged from 0.21-13.5, with a median value of 0.70. The median fog /rain ratio from the isotope collectors was 0.21. Soil water isotopic composition reflected the large rainstorms, with little cloud water input. Isotopic composition of M. *polymorpha* sap at this site was similar to soil water, suggesting that the trees tap a deeper water source than at the windward site. Results from the study will lead to a better understanding of the relationship of cloud forests to recharge and streamflow along mountain slopes.

URL: http://water.usgs.gov/nrp/proj.bib/hawaii/maui_fog.htm

### H32E-05 1500h

## Persistent Spatial Variability of Throughfall Amounts and Intensity Beneath Forest Canopies

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Forest canopies are important modifiers of precipitation, both spatially and temporally. Because of the nonlinearities in water fluxes through soils, understanding precipitation redistributions in space and time will allow advances in predicting rainfall-runoff processes in forested watersheds. We found distinct spatial patterns of throughfall persisting in time in three forest stands in the Pacific Northwest, USA. Variograms of storm-total throughfall, collected in small gauges, differed by stand but were consistent among storms within each site. Nondimensionalizing throughfall amounts in the small gauges revealed persisting wet and dry areas, which preserved variograms through time deterministically instead of simply statistically. Cumulative distribution functions of study-total throughfall at each gauge were useful for characterizing persistence of throughfall variability. We measured throughfall intensity within storms using larger throughfall gauges attached to tipping buckets. By comparing these data to rain gauges in nearby openings, we quantified attenuation of rainfall intensity by canopies. There was both temporal and spatial variability in intensity attenuation. Spatial variability was low under a homogeneous canopy of young conifers, but high under a heterogeneous canopy of old-growth conifers. High intensity attenuation was generally correlated with low storm-total throughfall. These persisting patterns in throughfall amounts and intensity suggest there may be corresponding variation in infiltration and soil water movement.

### H32E-06 1515h

## Linkages between soil respiration and its physical and biological drivers at multiple spatial scales in a lodgepole pine (*Pinus contorta*) forest

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The purpose of this study was to characterize the relationships between soil respiration and some physical and biological properties of the soil that drive it, including soil temperature, soil water content, and litter depth. We also examined spatial patterns of each factor at the hillslope scale (13,000 $m^2$) and the individual plot scale (25 $m^2$) to identify spatial correlations using geostatistics. Our study area in the Medicine Bow Mountains of Wyoming encompasses adjacent North- and South-facing slopes at 2800 m elevation. Lodgepole pine (*Pinus contorta*) forest dominates the watershed, and spruce (*Picea engelmannii*), fir (*Abies lasiocarpa*) , and aspen (*Populus tremuloides*) are also present where soils are moist. Within each spatial scale, semi-variograms were used to identify the spatial range of soil respiration and its drivers. At the plot scale, soil respiration drivers exhibited stronger spatial patterns than soil respiration. At the hillslope scale, aspect played an important role in the relationships between soil respiration and these drivers. Drivers of soil respiration are still poorly understood at varying spatial scales; this project aims to better quantify these linkages for improved modeling of carbon fluxes at the watershed scale.

# H32F MCC: 3022 Wednesday 1340h

## Watershed Processes and Linkages to Regional and Watershed Patterns in Stream Channel Morphology I

*Presiding:* **J M Faustini,** Oregon State University**; B P Bledsoe,** Colorado State University

### H32F-01 1345h INVITED

## Hydraulic Control on the Spatial Distribution of Chinook Salmon Spawning Gravels in Central Idaho: Integrating Reach-Scale Predictions via Digital Elevation Models

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We examined hydraulic controls on the spatial distribution of chinook salmon spawning gravels in the Middle Fork Salmon River, a mountain basin in the Frank Church Wilderness of central Idaho. Reach-scale predictions of substrate size were integrated via a digital elevation model (DEM) to assess the basin-scale distribution of spawning gravels. Channel reaches were delineated between 40' contour intervals within the DEM, and were further subdivided at tributary junctions. Reach-scale predictions of channel competence (size of sediment that can be carried by the channel) were determined from the Shields equation evaluated at bank-full stage and empirically adjusted for local channel roughness and sediment supply (both as functions of bank-full shear stress). We use the bank-full shear stress because channel morphology and sediment size in coarse-grained rivers are commonly adjusted to bank-full flow. Shear stress in the Shields equation was predicted from a depth-slope product, with bank-full depth determined from a basin-specific hydraulic geometry relationship (expressed in terms of drainage area), and channel slope was determined from the DEM. Data for the empirical relationships were derived from field measurements of 121 channel reaches. The final grain-size prediction is a function of drainage area and slope, values readily obtained from the DEM. Field observations of chinook salmon spawning sites within the study area were used to define preferred substrate sizes. Predicted grain sizes were compared to preferred values to determine the basin-scale distribution of suitable spawning gravels. To test the model, predicted spawning-gravel sites were compared to an 8 year record of observed redd locations. Results demonstrate that nearly 90% of the redds (n=5135) occurred within reaches predicted to have suitable substrate sizes, with 98% of those reaches predicted to have a pool-riffle morphology. Moreover, redd densities were roughly 3 times greater in reaches predicted to be suitable. However, redds tended to be clustered in upstream portions of the accessible network, rather than evenly distributed throughout the suitable reaches. This may be due to a variety of factors, including 1)depressed population sizes and preferential selection of the best spawning sites; 2)loss of chinook salmon phenotypes that once spawned in currently underutilized habitats, and fidelity of remaining subpopulations; or 3)constraints imposed by environmental factors other than substrate size (e.g., stream temperature, velocity, scour regime, hyporheic flow, winter icing, etc.). Sources of error in our predictions are largely due to scatter in the correction for channel roughness and sediment supply. Correspondence between observed channel slopes and those predicted from the DEM are reasonably good. Although reach-scale predictions perform well, spawning site selection likely depends on subreach hydraulics and textural patches that are not accounted for in our analysis. Nevertheless, subreach textural variability can be associated with reach-scale channel type, allowing empirical adjustment for the potential subreach area available for spawning.

### H32F-02 1405h INVITED

## How to Reach Across a Basin: Integrating Basin-Scale Interactions to Reach-Scale Predictions

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Many reach-scale aspects of channel morphology, habitat structure, and disturbance regime arise from basin-scale interactions. Valley-floor landforms and channel types reflect a potentially long history of events that have mobilized sediment from upstream and upslope. Processes that move sediment and woody debris act over a basin topography that controls the location of sediment delivery to channels. Subsequent movement and fluvial rearrangement of this sediment is modulated by valley morphology and channel-network structure. These controls on sediment production, movement, and storage can be inferred using digital elevation data coupled with simple models of sediment mobilizing processes. This characterization of the active processes can then be used to infer the spatial distribution of channel morphology and habitat structure. Coupled with climatic and anthropogenic drivers that produce temporal variability in the rate of sediment and wood production (storms, fires, road construction), these tools can be used to characterize channels throughout a basin in terms of the distribution of morphologies and habitat structures that can arise at each reach. We'll describe GIS modeling tools developed for debris-flow-prone landscapes of the Pacific Northwest and describe our strategy for verifying and using model predictions.

### H32F-03 1425h

## Detecting Cumulative Effects on Low-gradient Streams in the Central Sierra Nevada, California

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