H32D MCC: 3024 Wednesday 1340h

The Effects of Best Management Practices on Water Quality, Runoff Processes, and Sediment Transport I

(joint with B, PA)

Presiding: **D A Burns,** U.S. Geological Survey**; B McGlynn,** Montana State University

H32D-01 1345h INVITED

Improving Water Quality With Conservation Buffers

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Conservation buffer technologies are new approaches that need wider application. In-field buffer practices work best when used in combination with other buffer types and other conservation practices. Vegetative barriers may be used in combination with edge-of-field buffers to protect and improve their function and longevity by dispersing runoff and encouraging sediment deposition upslope of the buffer. It's important to understand how buffers can be managed to help reduce nutrient transport potential for high loading of nutrients from manure land application sites, A restored riparian wetland buffer retained or removed at least 59 percent of the nitrogen and 66 percent of the phosphorus that entered from an adjacent manure land application site. The Bear Creek National Restoration Demonstration Watershed project in Iowa has been the site of riparian forest buffers and filter strips creation; constructed wetlands to capture tile flow; stream-bank bioengineering; in-stream structures; and controlling livestock grazing. We need field studies that test various widths of buffers of different plant community compositions for their efficacy in trapping surface runoff, reducing nonpoint source pollutants in subsurface waters, and enhancing the aquatic ecosystem. Research is needed to evaluate the impact of different riparian grazing strategies on channel morphology, water quality, and the fate of livestock-associated pathogens and antibiotics. Integrating riparian buffers and other conservation buffers into these models is a key objective in future model development.

H32D-02 1405h

Matching Form to Function in Forestry Riparian Buffer Zones

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Riparian buffer zones are common tools for preventing negative effects of forest management on streams. Following experience in agricultural settings, buffers have been expected to mitigate temperature increases, decrease inputs of sediment and nutrients, prevent disturbance to stream channels, and provide organic debris. Our research in several forested watersheds of the Pacific Northwest and southeastern USA has revealed these functions are not universally important, and that directed management in riparian zones can enhance some functions without unduly compromising others, as demonstrated by three examples. First, riparian zones in forested watersheds rarely function as "filter strips" to remove sediment from overland flow. Instead, buffers usually prevent sediment inputs to streams mainly by reducing disturbance in and near channels. Second, although shade from riparian vegetation prevents stream temperature increases, temperature effects of removing vegetation may be only localized in gaining streams. Third, active management of riparian vegetation can potentially provide more large woody debris than undisturbed buffers. We suggest that science must inform efforts to design effective BMPs such as buffer strips because of substantial variability in dominant processes and desired values. We further suggest that applying scientifically based BMPs tailored to specific landscapes can improve BMP effectiveness.

H32D-03 1420h

Headwater Stream Temperature Response to Forest Harvesting in Coastal British Columbia, Canada: Influences of Riparian Buffer Width, Channel Morphology and Weather

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Forest harvesting can influence stream temperature regimes, and the potentially deleterious impacts of higher temperatures on salmonids and other species have generated significant debate. One common approach to protecting streams is to leave a riparian buffer to provide shade. However, little information has been collected on the effectiveness of different buffer widths. We report the results of a 6-year field experiment to evaluate the effects of different riparian buffer widths on stream and riparian ecosystems, including stream temperature response, in headwater streams in coastal British Columbia. The experiment included 13 streams, with at least three being assigned to each of four treatments, including no harvesting (80 yr-old second growth conifer riparian forest), clear-cut harvesting with 10 m and 30 m riparian buffers, and clear-cut harvesting with no buffer. Regression analysis was used to calibrate the pre-harvest data for each treatment stream with one of the control streams, to provide a basis for estimating post-harvest treatment effects. Autoregressive and heteroskedastic errors were included in the regression model, because stream temperature exhibited serial correlation and the error variance increased with stream temperature. Temperature response was substantial in the clearcut treatments with no buffers, with maximum temperatures increasing by up to 8 degrees C. The magnitude of temperature response amongst the no-buffer treatments varied with channel morphology, particularly in relation to bank shading and stream depth. The treatment effect for daily maximum water temperature increased with decreasing flow and increasing maximum air temperature on the current day, and also exhibited significant autocorrelation, indicating that the sequence of daily weather conditions can influence the magnitude of temperature response.

H32D-04 1435h

Removing Phosphorus from Milkhouse Wastewater Using Vegetative Filter Strips

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Vegetative filter strips (VFS) are commonly used BMPs to control agricultural pollutants. In watersheds supplying drinking water to New York City, VFS are installed to remove phosphorus (P) from milkhouse wastewater and barnyard runoff to reduce P inputs to the drinking water reservoirs and minimize eutrophication. Monitoring wells were installed within two VFS and the application of chloride tracer was used to investigate flow paths and soluble reactive P (SRP) removal. The SRP concentrations in the wells were highest (generally over 10 mg/l) near the wastewater discharge point, while the Morgan's soil test P was high (over 60 mg/kg) in the downslope area of the VFS. Although P sorption isotherms indicate these soils (pH of 6.5) have high potential to remove P, the soil P accumulations were not occurring in the same area as the highest well water concentrations. Early chloride breakthroughs showed that milkhouse waste flowed preferentially in the VFS through locally saturated areas. The accelerated surface flow contributed to rapid transport of SRP in the wastewater to the downslope area of the VFS, resulting in less SRP removal. Although VFS of 33 to 40m long for the two sites, respectively, eventually reduced SRP to lower than 0.2mg/l in most cases, SRP was less effectively removed in areas where soil saturation occurred. The anaerobic condition of the locally saturated area apparently reduced opportunity for soil P sorption to Fe oxides in these sites. In order for the VFS to be more effective at P removal, efforts to distribute wastewater more uniformly to avoid soil saturation should be considered in new designs.

H32D-05 1450h INVITED

A Reassessment of the Expanded EPA/ASCE National BMP Database

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The purpose of the National Stormwater BMP Database is to improve the quality and consistency of information on the performance of BMPs. The USEPA/ASCE National BMP Database has grown significantly since the first evaluation of BMP performance data in the database was completed in 2000. The project team is currently performing a re-evaluation of the data contained in the database to assess the overall performance of BMPs as well as compare BMP design attributes to performance. To date the project has included: 1. Development of scientifically developed protocols for collection and reporting of BMP performance information 2. Establishment of database to store BMP monitoring and design data in standard format 3. Establishment of standard techniques for data collection, storage, reporting, and analysis 4. Evaluations of BMP performance and potential technical BMP design improvements The evaluations include the assessment of various BMP types as categorized in the database with regards to their ability to reduce runoff volumes as well as improve effluent quality. Certain BMP types may reduce the volume of runoff through evapotranspiration and/or infiltration, as opposed to BMPs that are more "sealed," such as wet ponds, wetlands, and vaults. Runoff reductions directly reduce pollutant loading as does improved effluent quality. On average, dry detention basins were found to reduce runoff volumes by an average of 30% (comparison of inflow to outflow), while biofilters reduced volumes by almost 40%. As expected, wet ponds, wetlands, and hydrodynamic devices, and retention ponds show little or no runoff volume reductions. BMP types vary with regards to effluent quality that is achieved. BMPs such as wet ponds and wetlands appear to achieve lower concentrations in effluent quality than other BMPs such as detention ponds (dry) and hydrodynamic devices. These differences vary with pollutant type. With more data available, analyses of BMP design versus performance show statistically valid results. For example, a relationship (ratio) between the treatment volume of retention ponds (with wet pools) versus the average size storm event volume monitored has been established, showing that those with a ratio of 1 or greater have been observed to achieve significantly better effluent quality. One of the key project findings is that pollutant percent removal reporting is not a valid indicator of performance, unless treatability information (such as settling velocity data) is provided. The recommended measures for BMP performance include: 1. How much stormwater runoff is prevented? (Hydrological Source Control) 2. How much of the runoff that occurs is treated by the BMP or not? (bypass or beyond treatment flows) 3. Of the runoff treated, what is the effluent quality? (Are water quality objectives being met?) This paper also briefly overviews the Urban Stormwater BMP Performance Monitoring ("Manual") (Strecker, et. al., 2002) that was developed by integrating experience gleaned from field monitoring activities conducted by members of ASCE's Urban Water Resource Research Council and through the development of the ASCE/EPA National Stormwater Best Management Practices Database. The Manual is intended to help achieve stormwater BMP monitoring project goals through the collection of more useful and representative rainfall, flow, and water quality information.

URL: http://www.bmpdatabase.org

H32D-06 1510h

Selenium removal during a flood experiment: Best management practice for a contaminated wetland?

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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 nutrient 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.

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 hillslope 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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