H51E-1133 0830h POSTER

Erosion Rates Over Millennial and Decadal Timescales: Measurements at Caspar Creek and Redwood Creek, Northern California

Ken L Ferrier[1] (freedom@eps.berkeley.edu)

James W Kirchner[1] (kirchner@seismo.berkeley.edu)

Robert C Finkel[2] (rfinkel@llnl.gov)

[1]Department of Earth and Planetary Science, University of California, Berkeley, 307 McCone Hall, Berkeley, CA 94720-4767, United States

[2]Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, MS L-206 7000 East Ave, Livermore, CA 94550-9234, United States

Erosion rate measurements are essential for modeling landscape evolution and for discerning how sediment loading affects stream ecosystems. Cosmogenic nuclides such as ^{10}Be in stream sediments can be used to measure whole-catchment erosion rates averaged over thousands of years, a timescale that is unobservable by other methods. Comparing long-term erosion rates from cosmogenic nuclides with short-term sediment yields can shed light on erosional processes and on the effects of land use on sediment delivery to streams. Using cosmogenic ^{10}Be, we measured erosion rates averaged over the past several thousand years at Caspar Creek and Redwood Creek in Northern California. Sediment yields have also been measured at Caspar Creek since 1963 using sediment trapping and gauging methods, and sediment yield data have been collected at Redwood Creek since 1974. The cosmogenic ^{10}Be signature of Caspar Creek sediments indicates an average erosion rate of 0.13 mm/yr, which agrees with the short-term sediment yield data within error. The cosmogenic ^{10}Be signature of Redwood Creek sediments implies an average long-term erosion rate of 0.3 mm/yr, which is in rough agreement with traditional measurements of stream sediment flux. These results imply that the rate of sediment delivery to Caspar Creek and Redwood Creek over the past few decades is broadly consistent with the long-term average rate of sediment production in these watersheds.

H51E-1134 0830h POSTER

Lichenometry's Black Box: Demographic Characteristics of *Rhizocarpon geographicum* and *Pseudophebe pubescens* Inferred from Whole Population Size-Frequency Distributions

M. G. Loso[1] (831-459-2551; mloso@es.ucsc.edu)

D. F. Doak[2] (831-459-4374; doak@biology.ucsc.edu)

[1]Earth Sciences, Univ. of California, Santa Cruz, CA 95064, United States

[2]Ecology and Evolutionary Biology, Univ. of California, Santa Cruz, CA 95064, United States

For decades, geologists have used the inferred ages of crustose lichens to date geomorphic landforms. Traditionally, lichenometry relies upon the assumption that the size of the largest lichen thallus in a population reliably predicts the age of the landform. But in a given population, both the largest lichens and the probabilities of finding them are determined by the size frequency distribution of the population, a demographic characteristic controlled by the population's particular rates of colonization, growth, and mortality. These rates, and their variability, are driven by biological processes that are difficult to observe directly in the slow-growing lichen species favored by lichenometrists. To improve our understanding of these demographic characteristics- lichenometry's "black box"- we documented the size-frequency distributions of two lichen species, *Rhizocarpon geographicum* and faster-growing *Pseudophebe pubescens*, in populations growing on well-dated lakeshores in south-central Alaska. We sampled whole populations on 5 lakeshores ranging in age from 53 to 172 years old, assembling a dataset of over 15,000 measurements. The results reveal distinct trends shared by both species. On lakeshores of all ages, they consistently maintain a small modal size class ($\sim$ 3mm for *Rhizocarpon*, $\sim$ 8 mm for *Pseudophebe*), and frequency declines exponentially above the mode, extending to the largest size classes on the oldest surfaces. These data serve to constrain numerical demographic models of the full lichen population. Model results imply that colonization does not occur as a single pulse after substrate exposure, but instead occurs steadily after some initial lag. These lichens also undergo substantial mortality. For both species, models using steady mortality of 2%/year fit the data significantly better than models assuming zero mortality. This result could explain the discrepancy between lichenometrists' "great growth," a common empirical observation that largest lichen sizes increase most rapidly with age on the youngest substrates, and the seemingly contrary observation that careful repeated measurements of individual lichen thalli often show lichen radial growth rates increasing with thallus age. More importantly, this and other results offer the opportunity to assess quantitatively the accuracy and utility of lichenometric dating in a variety of contexts.

H51E-1135 0830h POSTER

Representing the Landslide Magnitude-Frequency Relation of a Glaciated Basin, Coastal British Columbia.

Francesco Brardinoni[1] (1-604-822-2663; fbrardin@geog.ubc.ca)

Michael Church[1] (mchurch@geog.ubc.ca)

[1]UBC Geography, 1984 West Mall, Vancouver, BC V6T 1Z2, Canada

Magnitude-frequency analysis is used here as a statistical method to quantify the erosion produced by rapid shallow failures in a glaciated basin of coastal British Columbia. Coupling air photo and ground-derived data we prove that the deviation from power-law distribution observed for small magnitude is an artefact of detection deficiencies. However, the total distribution shows to be not sensitive to the occurrence of small mass failures and total erosion remains well represented in the API-derived data. Our dataset also denotes a real deviation from simple scaling at much higher magnitudes, the cause of which is currently under investigation.

H51E-1136 0830h POSTER

Soil-Forming Rates and Processes on Quaternary Moraines in Southern Patagonia

Daniel Douglass[1] (douglass@geology.wisc.edu)

James G Bockheim[2] (608-263-5903; bockheim@wisc.edu)

David M Mickelson[1] (davem@geology.wisc.edu)

Bradley S Singer[1] (bsinger@geology.wisc.edu)

Michael Kaplan[3] (mkaplan@geo.edu.ac.uk)

[1]University of Wisconsin, 1215 W Dayton Street, Madison, WI 53706-1299, United States

[2]University of Wisconsin, 1525 Observatory Drive, Madison, WI 53706-1299, United States

[3]University of Edinburgh, Department of Geology, Edinburgh EH8 9XP, United Kingdom

Thirty-four pedons on 12 moraines (4 moraine groups), were examined in Santa Cruz province, Argentina. Ages of the four moraine groups are 16-24, 110-185, 200-760, and 760-1016 ka based on cosmogenic surface exposure dates and stratigraphic relationships to 40Ar/39Ar dated basalt flows. The soils are classified primarily as Calcic Haploxerolls and occur under short grass steppe with about 200 mm yr-1 precipitation on glacial sediments derived from igneous and metamorphic rocks of the Andean Cordillera. The dominant soil-forming processes are melanization (accumulation of organic matter) and calcification (accumulation of secondary carbonates). Based on limited sampling, dust in Patagonia is enriched in organic carbon and CaCO3. Age related differences in soil development on moraines were tested with ANOVA and reported at the p <0.05 level. A-horizon organic carbon quantities increase with age (1.3, 1.4, 2.4 and 2.4 kg m-2 for the four groups). The maximum carbonate morphology stage, thickness of the calcic (Bk) horizon, profile development index, and profile accumulation of calcium carbonate (3.3, 16.6, 42.1 and 31.8 kg m-2) increase with age. Rates of carbonate accumulation are similar for the youngest three moraine groups, but much lower for the oldest group (183, 118, and 140 as opposed to 40 g m-2 kyr-1). The implications of these data are: 1) soil OC may be stable in this environment and continue to accumulate in soils over very long time periods, 2) rates of carbonate influx in this area are significant but less that in other semiarid areas, and 3) these rates have been constant for the last few glacial-interglacial cycles, but an equilibrium is approached after about 800kyr.

H51E-1137 0830h POSTER

Quantitative Prediction Models of Landslide Dependent on Lithology

W.Y. Kim[1] (kwy@kigam.re.kr); B.G. Chae[1] (bgchae@kigam.re.kr); Y.C. Cho[1] (choych@kigam.re.kr); C.O. Lee[1] (colee@kigam.re.kr); K.S. Kim[1] (kks@kigam.re.kr); Y.S. Choi[1] (yschoi@kigam.re.kr)

[1]Korea Institute of Geoscience and Mineral Resources, 30 Gajeong-dong, Yuseong-gu, Daejeon 305-350, Korea, Republic of

The most common type of landslide in Korea is debris flow taken place on natural terrain covered by thin unconsolidated weathered rock or soil. The landslides are initiated by regolith failure at shallow depth. KIGAM research team has performed a research project to develop a quantitative prediction method of landslide. Detailed survey of landslides was conducted for 198 landslides among 1,600 landslides in a region of metamorphic rocks and granites, and 1,500 landslides in sedimentary rocks and volcanic rocks regions. The landslides were investigated at the scale of both 1:50,000 and 1:5,000 to obtain landslide triggering factors. The items investigated for each landslide are lithology, weathering degree, discontinuity, type of landslide, slope geometry, cross section of landslide, triggering position, length, width, depth and volume. Fourteen physical and mechanical properties of soil samples were tested for 139 specimens of undisturbed samples. In order to select landslide triggering factors, the investigated and tested items were analyzed using the logistic regression method. Seven factors from metamorphic rocks and granites were chosen as the triggering factors of landslides. Five factors were also chosen as the landslide inducing factors from sedimentary rocks and volcanic rocks. The logistic regression method produced two models of logit equations that can calculate absolute landslide probability. Because the computation results of logit equations present as type of percentage, it is easy for the common people to understand the meaning of landslide probability. Verification of the landslide prediction models showed more than 90% of prediction accuracy. Finally eight sheets of quantitative landslide probability map were produced based on the landslide prediction models at the scale of 1:5,000.

H51F MCC: 3022 Friday 1020h

Catchment Processes in the Tropics II

(joint with B)

Presiding: **R C Sidle,** Kyoto University**; D G Chandler,** Utah State University

H51F-01 1020h

Effects of Tropical Forest Conversion on Hydrologic Response: Process Implications for Potable Water and Sediment Budgets in Karstic Uplands

David G Chandler (435.797.7326; dchandle@mendel.usu.edu)

Dept. of Plants, Soils and Biometeorology , Utah State University, Logan, UT 84322-4820

Conversion forest to agricultural land has been attended by marked hydrological and ecological responses and has arguably made a considerable contribution to global change. These changes have been less well studied in the tropics than in temperate climates, yet the impact of such changes is more immediate for rural landholders in the tropic than for western, industrialized societies, who rely on infrastructure to buffer the effects of global change. The most immediate concern of upland farmers in Leyte, Philippines was the decreasing availability of water, both for household and agricultural use. They attributed the changes in hydrology to deforestation, but were unclear about the hydrologic processes involved. The primary goal of development organizations conducting projects in the region was soil conservation, through implementation of erosion control practices. This study was conducted to identify the mechanisms governing hydrologic change and soil loss in a succession of land uses. Forest removal was found to have less dramatic impacts on surface runoff than did subsequent changes in the soil associated with agricultural use. Soil erosion was more strongly associated with soil disturbance than with extent of surface runoff. The interplay between the shift in hydrologic processes and disturbance frequency for the agricultural land uses resulted in the proposed conservation practice exacerbating the erosion rates within the catchments. Although on site erosion for the pasture catchment was minimal, this treatment was found to have the lowest

infiltration capacity and likely contributed greatly to the loss of perennial springs in the uplands and erosion of lowland rice paddies. These results suggest that land uses and agricultural practices that maintain soil infiltration capacity will have the greatest success in maintaining local potable water sources and reducing soil erosion.

H51F-02 1035h

Suspended-Sediment Export From Four Small Montane Humid-Tropical Watersheds With Varying Land use and Lithology, Puerto Rico

Matthew C Larsen (7036485044; mclarsen@usgs.gov)

US Geological Survey, 436 National Center, Reston, VA 20192, United States

Intensive land-use conversion of forested landscapes to agricultural use accelerated in most of the global tropics during the 20th century and has resulted in large increases in soil erosion and suspended-sediment export. Fluvial sediment is one of the most abundant freshwater contaminants on earth. Stormflows episodically transport sediment to reservoirs, estuaries and in coastal waters where coral reefs are located. The sediment and associated contaminants such as pesticides, herbicides, and fertilizers, degrade water quality and are harmful to aquatic organisms in these areas. Improved understanding of the processes and rates of fluvial sediment transport in natural and anthropogenically disturbed settings enhances management of natural resources and aids in the establishment of standards for acceptable sediment concentrations. Four USGS WEBB (Water, Energy, and Biogeochemical Budgets) study watersheds in Puerto Rico (18^{o} latitude) were paired to compare and contrast the effects of land use and bedrock geology on suspended-sediment yield. Sediment concentration, calculated as sediment yield normalized to runoff, was more than three times greater in two watersheds in secondary forest and pasture compared to sediment concentration in watersheds in primary forest. The influence of lithology was comparable: sediment concentration in intrusive-bedrock (quartz diorite and granodiorite) watersheds was more than three times higher than sediment concentration in volcaniclastic-bedrock (volcanic sandstone, mudstone, and breccia) watersheds. These contrasts highlight the well-known effect of land use on sediment concentration and yield but also demonstrate the strong control of bedrock geology. Most importantly, the high sediment yields in the watersheds that were converted to pasture and secondary forest, even after 60 years of forest reestablishment, provide a glimpse into the future of tropical watersheds elsewhere that are now undergoing deforestation. Erosion rates observed in agriculturally-developed watersheds are substantial in regard to reservoir storage. Public water supply for the city of San Juan (population 1.6 million) is largely derived from surface-water storage. The principal San Juan reservoir lost approximately 60 percent of its storage capacity from siltation in the 40 years following impoundment in 1954. The reduced storage capacity resulted in severe water rationing for San Juan during several droughts during the past decade.

H51F-03 1050h

The Suspended-sediment Conveyor Belt in Humid Tropical Puerto Rico

Allen C Gellis (410 238-4281; agellis@usgs.gov)

US Geological Survey, 8987 Yellow Brick Road, Baltimore, MD 21237

The production, transport, and delivery of sediment from hillslopes to channels and to the sampling point in humid-tropical Puerto Rico can be visualized as a conveyor belt that is affected by hydrologic characteristics of the current event, previous events, and between events. In Puerto Rico a model of how the conveyor belt operates in four basins of differing land use (forest, pasture, cropland, and urban was developed using 3,096 suspended-sediment samples and 754 storm-generated runoff events collected from 1989 though 1995. Instrumented basin areas ranged from 3.26 km^2 to 19.4 km^2. Statistical analysis included multiple regression and principal components analysis. The suspended-sediment conveyor belt operates differently as sediment supply increases. In the forest and pasture basins, sediment sources are minimal, typically as landslides, and large storm-generated runoff events supply sediment to the channel where it is deposited and becomes the source of sediment for the next runoff event. Clockwise hysteresis loops are common in the forested basin and support the idea that the channel is a source of sediment. In the forest basin, runoff and rainfall occurring between events flush some of the sediment in storage, while in the pasture basin, rainfall and runoff occurring between events supply sediment to the channel. In the cropland basin, sediment sources increase, and large rainfall events supply sediment to the channel where it is flushed by the storm-generated runoff. Rainfall between events also supply sediment to the channel where it is flushed by high flow between events. In the urban basin with widespread sediment sources from construction activities, storm-generated events and high flows between events flush sediment from hillslopes and channels. Sediment is made available on hillslopes by construction activities such as land clearance and bulldozers. As sediment supply in a basin increases, channel hysteresis loops trend from clockwise to counterclockwise. Disturbance in watersheds draining fine grain soils will more likely exhibit counterclockwise hysteresis loops as sediment that is entrained remains in suspension longer, often peaking after the peak flow. The role of previous storm events in flushing sediment becomes more important as disturbance in a basin increases.

H51F-04 1105h

Runoff nutrient and suspended sediment fluxes, cycling, and management in southern Kaneohe Bay, Hawaii

Stephanie Ringuet[1] (808-956-2422; ringuet@soest.hawaii.edu)

Charles W Young[1] (cwyoung@soest.hawaii.edu)

Daniel J Hoover[1] (dhoover@soest.hawaii.edu)

Eric Heinen De Carlo[1] (808-956-5924; edecarlo@soest.hawaii.edu)

Fred T Mackenzie[1] (fredm@soest.hawaii.edu)

[1]Department of Oceanography, 1000 Pope Road University of Hawaii, Honolulu, HI 96822

Urban runoff and its impact on water quality in Hawaii, especially after heavy rainfall, is highly dynamic. In the past, water quality was determined through "grab samples" that were merely snapshots in time of an ever-changing environment. In contrast, continuous measurements of water quality can capture data that reflect the effects of significant storm runoff events unobtainable using even frequent manual sampling. Continuous multiparameter monitoring facilitates investigation of the both the magnitude and persistence of impacts of storm runoff on coastal waters, which can eventually be related to the health of coral reef ecosystems. Taking advantage of recent technological developments in oceanographic instrumentation, our study assembled an instrument package dubbed Coral Reef Instrumented Monitoring Platform (CRIMP). CRIMP was designed to include probes that measure physical and biological parameters (temperature, salinity, pH, dissolved oxygen, turbidity, and chlorophyll-a), nutrient analyzers (nitrate and phosphate), and a particle analyzer based on laser in-situ scattering and transmissometry. Various components of the CRIMP were previously used in conjunction with grab samples with the objective of elucidating the water quality of southern Kaneohe Bay and its relationship to physical, biological, and chemical processes operating in the bay, and to coral reef ecosystems. All instruments are now being combined on the CRIMP, and will allow us to study in near real time changes in fluvial inputs to the bay during storm runoff conditions and their impact on bay water quality and the coral reef ecosystem. In this presentation we discuss effects of freshwater delivery on adjacent coastal waters during high rainfall episodes (May 2002 and Feb 2003) that result in large runoff events and increased nutrient loading to coastal waters. Dissolved inorganic nitrogen to phosphorus ratios (DIN:DIP) in the Bay normally range from 2 to 4, suggesting a nitrogen-limitation that has been confirmed by nutrient-enrichment experiments. Elevated DIN:DIP values for storm runoff (25) change significantly the proportion of dissolved nutrients available for biological uptake. Significant increases in Chl-a concentrations in the bay a few days after storms suggest that phytoplankton growth was stimulated by the excess nutrients. The extremely low phosphate levels combined with the very high DIN:DIP values in Bay waters imply that phosphorus was the ultimate limiting-nutrient. Therefore, stream runoff has the potential of shifting the "normal" nitrogen-limited environment into a phosphorus-limited ecosystem. This shift has consequences for the management of fluvial nutrient inputs to Kaneohe Bay.

H51F-05 1120h

Channel Initiation on Slopes and Roads in a Tropical Montane Watershed in Northern Thailand

Spencer Wood[1] (208-426-3629; swood@boisestate.edu)

James P McNamara[1] (208-426-1354; jmcnamar@boisestate.edu)

Alan Ziegler[2] (66 6 1978731; adz@Princeton.EDU)

[1]Department of Geosciences Boise State University, 1910 University Dr., Boise, ID 83725

[2]Geography National University Singapore , 1 Arts Link Kent Ridge, Singapore 656777, Singapore

The Pang Khum Experimental Watershed in Northern Thailand has been the site of ongoing hydrologic studies since 1997. Current efforts are focused on quantifying the impacts of agricultural practices versus new unpaved roads on sediment delivery to streams. To support this effort, we conducted a field survey of channel initiation mechanisms on hillslopes and roads in the watershed and modeled the boundaries of erosion regimes in slope-area space using a high resolution digital elevation model. Field results show that three channel initiation mechanisms operate in the watershed: 1) shallow landsliding, 2) erosion by overland flow, and 3) spring sapping. Locations susceptible to these processes plot in distinct fields on a graph of slope versus area, and channel heads on rods plot in yet another field. Further, channel heads formed by any of these mechanisms fall in a region on a slope area plot that separates channeled and unchanneled convergent topography.

H51F-06 1135h

Bedload transport in a tropical headwater catchment

Alan D Ziegler[1,2] (+66 6197 8731; ADZ@HAWAII.EDU)

Thomas W Giambelluca[2] (+1 808 956 7390; THOMAS@HAWAII.EDU)

Ross A Sutherland[2] (+1 808 956 3524; SUTHERLA@HAWAII.EDU)

Mike A Nullet[2] (+1 808 956 8465; MNULLET@HAWAII.EDU)

[1]GEOGRAPHY — NATIONAL UNIVERSITY SINGAPORE, 1 ARTS LINK — KENT RIDGE, SINGAPORE 656777, Singapore

[2]GEOGRAPHY — UNIVERSITY OF HAWAII, 2424 MAILE WAY 445 SSB, HONOLULU, HI 96822, United States

Multi-year observations reveal a distinct seasonal pattern in the transport of bedload material in stream draining a 94-ha headwater basin in northern Thailand. The patterning is related to the presence of a monsoon rainy season, during which 90% of the annual 1200-1400 mm of rainfall occurs. Mean daily bedload transport during the wet season (mid-May through October) is 3-4 times greater than that during the drier months. More than 70% of the annual bedload total is mobilized during the wet season. A clock-wise hysteresis pattern characterizes the annual time series, such that more material is mobilized per unit discharge during the wet months than the drier months. This phenomenon results, in part, from two processes related to the monsoon climate regime and the current land-use: (a) large volumes of bedload are transported during a handful of short, flashy runoff events; and (b) bedload material is continually re-supplied during the wet period by runoff entering the stream from the road network. Also apparent in the annual transport pattern is a coarsening of bedload transported during the wettest months, when mean daily stream flow is 4-5 greater higher than that during the drier months. The size of material transported during storm events appears to be limited by the bed architecture (e.g., imbrication) up to a threshold discharge of about 2/3 bank full discharge (QBF = 0.5 cms). In five years of monitoring, QBF has been exceeded only once. The largest stone transported during that event was 10.65 kg; the diameter of the b-axis was 0.21 m.

H51F-07 1150h

Measuring and Modeling the Effects of Development on Sediment Production and Delivery, St. John, U.S. Virgin Islands

Carlos E Ramos-Scharron[1] (970/491-2774; cramos@cnr.colostate.edu)

Lee H MacDonald[1] (970/491-2774; leemac@cnr.colostate.edu)

[1]Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University, Fort Collins, CO 80523, United States

Increases in sediment delivery rates into tropical marine environments may pose a serious threat to nearshore coral reef communities. The island of St. John in the U.S. Virgin Islands is at particular risk because the areas outside of the Virgin Islands National Park are being subjected to rapid development, 80% of its land surface has slopes greater than 30%, and the average annual erosivity is 13,500 MJ mm ha^{-1} hr^{-1}. The objectives of this study were to: (1) measure erosion rates from a variety of anthropogenic and natural sources; and (2) develop a GIS-based model to estimate basin-scale increases in sediment delivery. Sediment production rates were measured from unsurfaced roads, road cutslopes, undisturbed hillslopes, streambanks, and treethrow. Unsurfaced roads had the highest erosion rates with values of up to 38 kg m^{-2} yr^{-1}, while road cutslopes generated only about 0.8 kg m^{-2} yr^{-1}. Since undisturbed areas generated only 0.001

kg m^{-2} yr^{-1}, unsurfaced roads can increase hillslope-scale sediment production rates by up to four orders of magnitude. Sediment production rates from erodible streambanks were estimated to be nearly 13 kg m^{-2} yr^{-1}, while uprooting of trees along stream margins was estimated to deliver 0.17 kg yr^{-1} of sediment per meter of stream length. The St. John Erosion model (STJ-EROS) uses a series of empirical sediment production models and sediment delivery ratios to estimate watershed-scale sediment yields in a GIS-based system. Using this model, the estimated sediment yields for the highly-developed 6.0 km^2 Fish Bay basin was 41 tons km^{-2} yr^{-1}, while the estimated sediment yield for the less-developed 4.3 km^2 Lameshur Bay basin was only 11 tons km^{-2} yr^{-1}. The model simulations suggest that current sediment yields are seven and four times above undisturbed conditions in the Fish Bay and Lameshur Bay basins, respectively. The predicted sediment yields are consistent with measured sediment yields and sedimentation rates in both Fish Bay and Lameshur Bay. In both cases actively used unsurfaced roads were identified as the dominant source of sediment. Cutslopes and streambanks played a secondary role in total sediment yields, while undisturbed hillslopes and treethrow contributed only minimal amounts.

H51F-08 1205h

Use of Water and Chemical Budgets to Quantify Interbasin Groundwater Transfer in a Lowland Rainforest

David P Genereux[1] (919-515-6017; genereux@ncsu.edu)

Michael Jordan[1] (ncsumj@aol.com)

David Carbonell[1] (dacarbon@unity.ncsu.edu)

[1]North Carolina State University, Marine, Earth, and Atmospheric Sciences, Jordan Hall, Raleigh, NC 27695-8208, United States

Previous water quality data strongly suggested the presence of interbasin groundwater transfer (subsurface seepage beneath topographic boundaries) into lowland rainforest watersheds at our study site in Costa Rica. This hypothesis was tested by using physical hydrologic data and water quality data (major ion concentrations) together to construct water and chemical budgets for two small adjacent watersheds at the site, the Arboleda (50 ha) and Taconazo (26 ha). Water budgets were computed for four consecutive 12-month periods beginning 1 December 1998 and ending 30 November 2002. Major ion budgets were computed for the latter two of these four budget years (12/00-11/01 and 12/01-11/02). Streamflow was continuously measured at a V-notch weir on each watershed, rainfall was measured with tipping bucket gauge in a nearby clearing, the (insignificant) change in water storage each budget year was estimated from the difference in water table elevation between the start and end of the year, and ET was estimated using Li-cor pyranometer data for our budget years and an empirical relationship between annual Priestly-Taylor ET estimates and annual pyranometer-based energy inputs at our site. Chemical data were used to distinguish between two chemically different waters (high-solute "bedrock groundwater" and low-solute "local water") in streamflow and in interbasin groundwater transfer (IGT). The water budgets unambiguously confirm a large IGT into the Arboleda watershed; on average about 15,000 mm of water entered the watershed each year, 5,000 from rainfall and 10,000 from IGT. About 44% of the IGT was bedrock groundwater, and the remainder was low-solute local water, chemically identical to subsurface water derived from rainfall onto the watershed. The Taconazo had little or no IGT (the water budgets and chemical data show no IGT of bedrock groundwater and a small positive IGT of local water that is not clearly distinguishable from zero, given the uncertainties in the budgets). Chemical budgets differed even more greatly than water budgets between the two watersheds, because of the large differences (factors of 13 to 30) in major ion concentrations between bedrock groundwater and local water. Annual Na, K, Mg, Ca, Cl, and SO4 budgets in the Arboleda were dominated by the roughly 4,400 mm of bedrock groundwater IGT (this accounted for about 93% of the inputs of these six ions to the watershed). IGT of local water accounted for about 4% of major ion inputs, and atmospheric deposition less than 3%. Results show the importance of IGT to the hydrologic and geochemical status of lowland rainforest in this area, and suggest the clear need to account for IGT in small watershed studies from which conclusions are to be drawn regarding the hydrogeochemistry of a particular land use or landscape type. IGT may be an important link between distant upland and lowland areas through an interposed groundwater system, and as such should be considered in both practical and research-oriented water resource questions.

H51G MCC: 3020 Friday 1020h

Nitrogen Sources and Cycling in Aquatic Systems II *(joint with B, OS)*

Presiding: **R B Alexander,** U.S. Geological Survey**; E W Boyer,** State University of New York

H51G-01 1025h INVITED

In-stream Processing of N: Implications for Regional N Losses

William H McDowell ((603) 862-2249; bill.mcdowell@unh.edu)

University of New Hampshire, Department of Natural Resources, Durham, NH 03824, United States

In many regions with high N inputs from human activity, large unmeasured N sinks have been inferred by comparing watershed inputs and outputs. One of the most likely N sinks is N uptake or denitrification within or adjacent to the stream channel. Recent research conducted as part of the LINX project helps to quantify some of these sinks and pathways. In 10 headwater streams, 15-NH4 was added at tracer levels and tracked through the various pools and fluxes of the N cycle. Results show that whole-stream enrichments (where N concentration is increased over background concentrations to determine N uptake) underestimate ambient rates of N uptake; that nitrification can be a very large fraction of NH4 uptake; that NH4 removal is related to Q and not biotic characteristics of the stream; and that NO3 uptake is often 10-fold slower than NH4 uptake. Given the very rapid N cycling in headwater streams, N losses in large rivers may be much more closely tied to these headwater processes than previously recognized. This is especially likely in watersheds where non-point source inputs are dominant.

H51G-02 1045h INVITED

Reach-Scale Application of ^{15}N-Enriched Nitrate Tracer for Measuring Denitrification in a Nitrate-Rich Stream

John Karl Bohlke[1] (703-648-6325; jkbohlke@usgs.gov)

Judson W Harvey[2] (703-648-5876; jwharvey@usgs.gov)

Mary A Voytek[2] (703-648-6894; mavoytek@usgs.gov)

[1]USGS, 431 National Center, Reston, VA 20192, United States

[2]USGS, 430 National Center, Reston, VA 20192, United States

Denitrification is one of the most important processes removing nitrate from streams and rivers before it is delivered to coastal ecosystems, but denitrification is difficult to quantify at the reach scale. We conducted a reach-scale isotopic tracer test to measure denitrification and other related processes in a nitrate-rich stream in the upper Mississippi River basin in September 2001. Bromide and ^{15}N-enriched nitrate were injected into the stream for 7 hours, yielding plateau concentrations in the stream for a distance of approximately 1 km. Concentrations of bromide were used to determine transport parameters and ground-water inputs. The concentrations and isotopic compositions of nitrate, nitrite, and nitrogen gas were used to determine reach-scale rates of nitrate addition and denitrification. This was done by combining the data in a forward-stepping numerical model that simulated a parcel of water moving through the reach, subject to denitrification, nitrification, ground-water discharge, and air-water gas exchange with changing temperature. The mass fluxes of nitrogen gas were dominated by discharge of denitrified ground water and air-water gas exchange, whereas the flux attributable to denitrification was relatively small. Nevertheless, there was systematic ^{15}N enrichment of the nitrogen gas going downstream indicating denitrification of surface-water nitrate. The reach-averaged rate of denitrification indicated by the isotopic tracer was equivalent to 130 μmol/m^2/hr (as benthic flux), 0.7 μmol/L/hr (as zero-order rate constant), or 0.01/hr (as first-order rate constant). This rate of denitrification should have been sufficient to reduce the nitrate load substantially within the tracer reach; however, the denitrification loss was more than offset by addition of nitrate from a combination of nitrification and discharge of ground-water nitrate. Consequently, there was a net increase in the nitrate load even though denitrification was a major sink for N in the stream. The in-stream nitrate isotopic tracer experiment provided a sensitive direct reach-scale measurement of denitrification in a nitrate-rich stream where other mass balance methods were not definitive because of insufficient sensitivity or offsetting sources and sinks.

H51G-03 1105h

Denitrification in Streams Impacted by Acid Mine Drainage: Effects of Iron, pH, and Potential Electron Donors

Jenny L Baeseman[1,2] (303-541-3026; baeseman@colorado.edu)

Richard L Smith[1] (303-541-3032; rlsmith@usgs.gov)

JoAnn Silverstein[2] (303-492-4211; joann.silverstein@colorado.edu)

[1]U.S. Geological Survey, 3215 Marine Street, Suite E-127, Boulder, CO 80303, United States

[2]University of Colorado, Civil Engineering Dept., Boulder, CO 80309, United States

Acid mine drainage (AMD) contaminates between 8,000 and 16,000 km of streams on U.S. Forest Service land in the Western United States and more than 7,000 km of stream in the Eastern U.S. Relatively little is known about nitrogen cycling in these acidic, heavy metal laden streams, however, denitrification can be inhibited under low pH conditions. The objective of this research was to examine AMD sediments for bacteria capable of denitrification. The process of denitrification is known to increase pH, which may be particularly important in acidic environments. Denitrification potential was assessed in AMD sediments from several Colorado AMD impacted streams ranging from pH 2.6 to 4.91, using microcosm incubations with fresh sediments. Added nitrate was immediately reduced to nitrogen gas without any lag period, indicating that denitrification was actively occurring in these environments. Rates varied from 0.33 to 2.52 umoles NO3-N/ g-sediment/ day depending on the site. The pH of the microcosms increased between 0.23 to 1.49 pH units in 5 days, depending on the site. Additional microcosm studies were conducted to examine the effects of iron concentrations (Fe2+ and Fe3+), initial pH conditions, and several potential electron donors. Addition of iron above ambient concentrations seemed to have little effect on denitrification rates, whereas rates increased with increasing initial pH. The addition of carbon and hydrogen stimulated denitrification rates, which in turn increased the rise in pH. These results suggest that not only is denitrification possible in AMD streams, it may also be a useful remediation option, if suitable methods can be found to stimulate activity.

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Tracer Tests and Peeper Samplers Used to Quantify In-Stream Nitrate Fluxes and Removal Rates in an Agricultural Watershed

Chris Ruehl[1] (cruehl@es.ucsc.edu); Andrew Fisher[1] (afisher@es.ucsc.edu); Geoff Wheat[2] (wheat@mbari.org); Marc Los Huertos[3] (marcos@cats.ucsc.edu); Carol Shennan[3] (cshennan@cats.ucsc.edu); Christine Hatch[1,3] (chatch@es.ucsc.edu)

[1]Earth Sciences Dept. University of California, Santa Cruz, 1156 High St., Santa Cruz, CA 95064, United States

[2]School of Fisheries and Ocean Sciences University of Alaska, Fairbanks, 245 O'Neill Building, Fairbanks, AK 99775, United States

[3]Environmental Studies Dept. University of California, Santa Cruz, 1156 High St., Santa Cruz, CA 95064, United States

The interface between surface water and ground water in riparian zones influences the quality and quantity of waters moving between linked reservoirs. Microbial respiration along this interface, for example, can act as a sink for dissolved nitrate, organic carbon, oxygen, and sulfate. We are investigating the removal of nitrate in a river draining the Pajaro Valley, a coastal, agriculturally-developed watershed that features elevated nitrate levels and groundwater pumping in excess of recharge (overdrafting). During summer base flow (discharge $\sim$ 0.3 m^3/sec), when no significant precipitation has fallen in the valley for 2-3 months, the Pajaro River consistently loses 0.1-0.2 m^3/sec of its discharge to the underlying alluvial aquifer along a 10-km reach east of Watsonville, CA. At the same time, nitrate concentrations (which are typically in excess of the EPA MCL), decrease by $\sim$30% along this reach. An observed a decrease in nitratre/chloride ratios along this reach suggests that biologic uptake (assimilative or dissimilative), not dilution, is primarily responsible for the observed decrease in nitrate concentrations. Sulfate/chloride ratios also decrease, and this along with pore water profiles obtained from streambed (peeper) samplers, suggests that dissimilitary nitrate reduction (denitrification) is primarily responsible for a significant fraction of the observed nitrate decrease. We performed a series of tracer experiments to quantify discharge, storage parameters, travel time, and nitrate