

**H31A MC: Hall D Wednesday 0830h****Impacts of Riparian Vegetation on Hydrologic and Geomorphic Processes I** (*joint with B, T*)**Presiding: A Collison**, Kings College London, Strand; **S J Bennett**, USDA-ARS**H31A-0228 0830h POSTER****The Influence of Large Woody Debris on Patterns of Sediment Storage in Steep Headwater Channels****Jeremy T Bunn**<sup>1</sup> (turlo@u.washington.edu)David R Montgomery<sup>1</sup> (dave@geology.washington.edu)<sup>1</sup>Dept. of Earth and Space Sciences, University of Washington, Box 351310, 63 Johnson Hall, Seattle, WA 98195

We conducted a field survey of sediment storage in and on the margins of steep headwater channels of the western Olympic peninsula that have experienced debris flows in the past decade. Our survey encompassed channels in both old growth and clear-cut forest stands.

Preliminary results indicate that:

1. Channels in clear-cut areas have significantly less large woody debris (LWD) than those in old-growth forests.

2. When LWD is present valley bends and slope breaks retain debris flow sediment, sediment is retained in the channel along most of the debris flow path, channel side-slopes are protected from debris flow scour, and sediment from side-slope failures is retained on channel margins.

3. In the absence of LWD channels are scoured to bedrock along much of the debris flow path, side-slopes are often scoured to bedrock or consolidated regolith, material from side-slope failures is generally not retained on the channel margin, and most sediment is deposited at the terminus of the debris flow, rather than distributed along the length of the run out path.

Substantial differences exist in the spatial pattern, volume, association with LWD, and grain size of sediment stored in and adjacent to steep headwater channels in old growth versus clear-cut forests. We explore implications for the timing and stability of sediment delivery to higher order streams.

**H31A-0229 0830h POSTER****Distorted Froude-scaled Flume Analysis of Large Woody Debris****Nicholas P. Wallerstein**<sup>1</sup> (nick@wallerstein.freeseerve.co.uk)Carlos V. Alonso<sup>2</sup> (alonso@sedlab.olemiss.edu)Sean J. Bennett<sup>2</sup> (bennett@sedlab.olemiss.edu)Colin R. Thorne<sup>1</sup> (colin.thorne@nottingham.ac.uk)<sup>1</sup>School of Geography, University of Nottingham, Nottingham NG7 2RD, United Kingdom<sup>2</sup>USDA-ARS National Sedimentation Laboratory, P.O. Box 1157, Oxford, MS 38655, United States

This paper presents the results of a movable-boundary, distorted, Froude-scaled hydraulic model based on Abiaca Creek, a sand-bedded channel in northern Mississippi. The model was used to examine the geomorphic and hydraulic impact of simplified Large Woody Debris (LWD) elements. The theory of physical scale models is discussed and the method used to construct the LWD test channel is developed. The channel model had bed and banks molded from 0.8 mm sand, and flow conditions were just below the threshold of motion so that any sediment transport and channel adjustment were the result of the debris element. Dimensions and positions of LWD elements were determined using a Debris Jam Classification Model (Wallerstein et al., 1997). Elements were attached to a dynamometer to measure element drag forces, and channel adjustment was determined through detailed topographic surveys. The fluid drag force on the element decreased asymptotically over time as the channel boundary eroded around the element due to locally increased boundary shear stress. Total time for geomorphic adjustment computed for the prototype channel at the Q2 discharge (discharge occurring once every two years on average) was as short as 45 hours. The size, depth and position of scour holes, bank erosion and bars created by flow acceleration past the elements were found to be related to element length and

position within the channel cross-section. Morphologies created by each debris element in the model channel were comparable with similar jams observed in the prototype channel.

**H31A-0230 0830h POSTER****Using Simulated Emergent Vegetation to Alter Stream Flow Direction Within a Straight Experimental Channel****Sean J. Bennett**<sup>1</sup> (bennett@sedlab.olemiss.edu)Taner Pirim<sup>2</sup>Brian D. Barkdoll<sup>2</sup> (cvbark@olemiss.edu)<sup>1</sup>USDA-ARS National Sedimentation Laboratory, P.O. Box 1157, Oxford, MS 38655, United States<sup>2</sup>Department of Civil Engineering, University of Mississippi, University, MS 38677, United States

River restoration programs often use vegetation to enhance the biological functionality, recreational opportunities, and aesthetic beauty of degraded stream corridors. Yet none has used vegetation for the purpose of inducing a straight channel to meander. A flume-based study was designed to alter the flow pattern within a straight, degraded stream corridor by using simulated emergent vegetation of varying density placed at key locations within the channel. Placement of vegetation zones was determined using an empirical relation for equilibrium meander wavelength based on the imposed flow rate. Surface flow velocities were quantified using particle image velocimetry. The study showed that (i) flow velocity can be markedly reduced within and near the vegetation zones, (ii) flow can be diverted toward the opposite bank, and (iii) vegetation density controlled the magnitude of these effects.

**H31A-0231 0830h POSTER****Riparian Vegetation: Controls on Channel Planform in Noncohesive Beds****Michal Tal**<sup>1</sup> (612-627-4582; talx0001@tc.umn.edu)Chris Paola<sup>1</sup> (cpaola@tc.umn.edu)Karen Gran<sup>2</sup> (kgran@u.washington.edu)<sup>1</sup>Department of Geology and Geophysics and St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN 55414, United States<sup>2</sup>Department of Earth and Space Sciences, University of Washington, Seattle, WA 98195, United States

Riparian vegetation has strong consequences for the channel planform and dynamics. An understanding of this role is key to accurate modeling of river systems, and may provide answers to fundamental questions concerning stream dynamics as well as bridge the various approaches to modeling channel evolution.

Vegetation on the flood plain works to constrain the flow of the river to a single channel by stabilizing banks and offering resistance to overbank flow. These controls were recently established through a set of controlled experiments at the St. Anthony Falls Laboratory. The runs were designed to determine how addition of vegetation affects channel form and flow dynamics. This was achieved by holding water discharge, sediment discharge, grain size, and slope constant, while making vegetation density the only variable between runs. Plants were grown while water discharge was half its channel-forming value. This work showed that as vegetation density increased there was a decrease in braiding intensity, lateral mobility, and width to depth ratios, and an increase in maximum scour hole depth, and channel relief.

While producing braiding experimentally has proven simple, no one has yet produced true dynamic meanders (i.e. high-amplitude bends that grow, cut off, and grow again). Present experimental studies at St. Anthony Falls Laboratory aim to investigate the role of vegetation in the development of a meandering river in otherwise insufficiently cohesive sand that would favor a more stable braided river system. The experiments begin with an unseeded bed into which a straight channel has been carved. Each cycle comprises a period of low discharge during which the bed is seeded with alfalfa seeds. The discharge is raised to a higher discharge only after the plants have grown to a height of about 20 mm (approximately 7 days). The duration of the high-flow stage is such that not more than 1020% of the channel width is eroded.

In addition to offering insight as to the several possible states that a river might be in, the experimental studies are intended to provide an understanding of how vegetation stabilizes single-thread channels, identify the nondimensional parameters that measure the stabilizing effects of vegetation, and realize the role of discharge variation in allowing plant colonization.

**H31A-0232 0830h POSTER****Mechanical Reinforcement and Enhanced Cohesion of Streambanks Using Common Riparian Species**Andrew J.C. Collison<sup>1</sup> (662-232-5702; collison@sedlab.olemiss.edu)Natasha L. Pollen<sup>1</sup> (662-281-5712; pollen@sedlab.olemiss.edu)Andrew Simon<sup>2</sup> (662-232-2918; simon@sedlab.olemiss.edu)<sup>1</sup>Department of Geography, Kings College, London, The Strand, London WC2R 2LS, United Kingdom<sup>2</sup>USDA-ARS National Sedimentation Laboratory, P.O. Box 1157, Oxford, MS 38655, United States

Vegetation plays an important role in the stabilization of riverbanks due to its effects on soil strength. Mechanical strengthening of the soil occurs as a result of their tensile strength and frictional properties. Increased cohesion due to roots (cr) is a function of the number and size of roots, the root area ratio (RAR), root-tensile strength, and the friction between the soil and the roots.

Field investigations were carried out in Southeastern, Central and Northwest USA to determine the root distributions and tensile strengths of various riparian species (Eastern Sycamore (*Plantanus occidentalis*), River Birch (*Betula nigra*), Black Willow (*Salix nigra*), Sweetgum (*Liquidambar styraciflua*), Longleaf Pine (*Pinus palustris*), Cottonwood (*Populus deltoides*), Alamo Switch Grass (*Panicum virgatum* 'Alamo') and Eastern Gamma Grass (*Tripsacum dactyloides*)). In situ root distributions were mapped to a depth of 1.0 m. Tensile-strength measurements were made using a modified boat winch connected to a load cell and wired to a datalogger to determine the maximum load applied to a root at failure. Increased cohesion due to roots was calculated using Wu et al.'s (1979) equation

The relation between tensile strength and root diameter is a non-linear decay function, with the smallest roots having the greatest strength per unit area. River birch and sycamore provide the greatest cr over the range of root diameters (about 8 kPa). In contrast, black willow, a common species used in restoration projects provides some of the lowest values of cr (about 2 kPa). For the tree species studied, although the smallest root size class (<1.0 mm) has the largest frequency of roots, and these smaller roots are stronger per unit area, the sum of their areas is insufficient to make a marked contribution to cohesion. However, of the grass species studied, Switch Grass has such a large number of these small roots that in this case the smaller roots are the main contributors to cr.

**H31A-0233 0830h POSTER****Floodplain Stabilization by Woody Riparian Vegetation During an Extreme Flood Along Headwater Tributaries of East Plum Creek, Colorado.****Eleanor R. Griffin**<sup>1</sup> (303-541-3041; egriffin@usgs.gov)J. Dungan Smith<sup>1</sup> (303-541-3004; jdsmith@usgs.gov)<sup>1</sup>U.S. Geological Survey, 3215 Marine Street, Suite E-127, Boulder, CO 80303, United States

Dense woody riparian vegetation acts to reduce flow velocities and boundary shear stresses on floodplain surfaces during large overbank flow events. Throughout the semi-arid west, woody riparian vegetation has been progressively thinned as the result of land use practices, such as grazing, and extensive reduction in beaver populations. Where woody vegetation is sparse, the floodplain surface is vulnerable to high rates of erosion during overbank flows. Unraveling of a floodplain surface occurs when flow is sufficiently deep and fast enough to erode the surface. Once erosion begins, it proceeds rapidly, leading to transformation from a narrow, single-threaded stream to a much wider, braided stream, as occurred along most of the mainstem of East Plum Creek, Colorado, during an extreme flood on June 16, 1965. Effects of this flood along headwater tributaries of East Plum Creek were documented in large scale (about 1:2,500) aerial photographs taken two days after the flood. The photographs along with available map information and field examination clearly show overbank flows were deep (on the order of 3 meters), yet the floodplain remained intact at sites with dense shrubs (sandbar willow). Two days after the flood, the shrubs were still lying bent over by the flood flow, and their canopy sizes and densities could be measured from the photographs. Within a 1.5-km reach, the downstream sequence of sites examined included: 1) locations where the floodplain surface and vegetation remained intact; 2) a location with less dense woody vegetation where the floodplain surface had just begun to erode; 3) locations with minimal woody vegetation, where the entire floodplain surface had begun to erode but a new channel had not yet formed; and 4) locations where erosion had caused a new, much wider

channel to form and almost all pre-flood woody vegetation was removed. Estimates of pre-flood vegetation types and densities were made at each of these four sites. Boundary shear stresses were then calculated for each site using a process-based model that included drag on the sandbar willows. When compared to critical shear stresses for erosion estimated for each site, calculated boundary shear stresses accurately predict the observed site of initiation of unraveling.

### H31A-0234 0830h POSTER

#### Precise Dating of Flood-Plain Stratigraphy Using Changes in Tree-Ring Anatomy Following Burial

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Determination of sediment deposition rates from stratigraphy is typically limited by a scarcity of chronological information. We present a method for precise dating of sedimentary beds based on the change in anatomy of tree rings upon burial. When stems of tamarisk (*Tamarix ramosissima*) and sandbar willow (*Salix exigua*) are buried, subsequent annual rings in the buried portions become narrower and vessels within the rings become larger. Observation of these changes can be combined with tree ring counts to determine the year of deposition of sedimentary beds that are at least 10 cm thick. Using a backhoe we dug trenches across the flood plain at three locations along the arroyo of the Rio Puerco, New Mexico. At each cross section we prepared a detailed stratigraphic description and excavated several tamarisks to depths as great as 5 meters. From each excavated tree we cut and sanded 10-50 slabs for tree-ring analysis. We cross-dated slabs within and between plants and used the burial signature in the tree rings to date all sedimentary beds in the stratigraphic profile near each plant. We then used the trench stratigraphy to convert depths of sediment deposition around individual trees to areas of deposition in the cross section. In the lower Rio Puerco introduction of tamarisk in 1926 occurred just prior to the beginning of channel narrowing and arroyo filling. Thus the tamarisks record a process of channel change to which they may have contributed. Aggradation has not been synchronous along the lower arroyo. For example, near Highway 6 and Belen, the flood plain has aggraded more than 2 m since 1970, while there has been little aggradation downstream at Bernardo. Much of the sediment deposition in levees at Highway 6 occurred during a flood in 1988. Future work will document longitudinal variation in the arroyo so that we can convert areas of sediment deposition in cross sections to volumes in the arroyo.

### H31A-0235 0830h POSTER

#### Numerical Modelling of Bed Topography and Bank Erosion Along Vegetated Meandering Rivers

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It is generally acknowledged that riparian vegetation influences the geomorphological dynamics of riverbanks. The nature of the impact depends on a wide range of variables related to vegetation, bank material and flow characteristics, many of which are spatially and temporally variable. It is often near impossible to isolate these variables in natural systems, and hence it is very difficult to perform controlled experiments to determine their effect. As a result of this, there are many uncertainties concerning the effects of riparian vegetation on channel morphology, riverbank erosion and meander migration. To help clarify this issue, numerical simulations have been undertaken to investigate these effects. The simulations are based on a two-dimensional depth-averaged numerical model (mRIPA) of bed topography and bank erosion for meandering rivers. mRIPA couples a two-dimensional flow and sediment transport model with a geotechnical bank-stability algorithm. This approach allows simulation of the interaction between hydraulic forces near the toe

of the bank and gravitational forces acting on the bank material, which together determine the long-term evolution of the river morphology. In this research mRIPA was developed further by introducing submodels designed to account for the effects of riparian vegetation in three distinct ways: (1) impact on bank material properties, (2) modification of flow hydraulics and (3) trapping of sediment in transport. The model has been used to run a series of what-if-simulations to investigate the influence of different vegetation parameters, such as species, density and positioning, in a range of idealized river geometries, as well as in natural rivers. Here we present some results from these simulations.

Key words: riparian vegetation, bank erosion, channel migration, meandering, numerical modelling

### H31B MC: Hall D Wednesday 0830h

#### Recharge and Vadose Zone Processes in Semiarid and Arid Regions I (joint with B)

**Presiding: F M Phillips, New Mexico Tech; C J Duffy, Penn State University; J Hogan, University of Arizona**

### H31B-0236 0830h POSTER

#### Simulations on Soil Moisture Variation in Nevada Test Site

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Studies of moisture flow in the unsaturated zone and contaminant transport in arid regions have been conducted in the last four decades to determine the suitability of sites for storage of hazardous and radioactive wastes and to evaluate the potential of contaminant migration to the underlying groundwater systems. Understanding the soil moisture profile in the unsaturated zone in arid regions is important for evaluating the groundwater recharge and the potential groundwater contamination. In this study, a soil hydrologic model was constructed and used to simulate the soil moisture variation in Nevada Test Site (NTS) soils. Its emphases are effects of soil textures, vegetation cover, and macropores on the soil-moisture variation in arid soils. Three typical soil textures: loamy sand, silty loam, and loam were used in this study of the NTS soils. Macropore parameterization has been incorporated into the model. Simulated results show that bare soil has a higher soil moisture content than vegetated soils, which is consistent with observed and modeled results. Soils with macropores have higher effective hydraulic conductivities and lower soil moisture content; more water drains deeper in the soil with macropores. The simulations in this study show that soil texture, vegetation cover, and macropores interact with each other to influence the soil moisture content in the arid region. The simulated temporal variation in soil moisture compares well with the observed. However, due to the lack of precise knowledge concerning macropore flow, transpiration rates, soil properties, and atmospheric processes of transpiration and precipitation, a discrepancy exists between the simulation and observation. It is expected that simulations will be improved through field experiment, laboratory measurements, and improved parameterization of the macropore flow.

### H31B-0237 0830h POSTER

#### Stable Oxygen and Sulfur Isotopes as Indicators of Recharge Processes and Groundwater Flow Paths in Tucson Basin, Arizona

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Groundwater in the Tucson Basin recharges from surface water in the major drainages entering the basin, as well as from fractures in crystalline rocks beneath the alluvial basin fill. Although varying transmissivities and pumping-induced upwelling complicate the groundwater flow paths, stable isotope characteristics enable us to infer groundwater sources and flow paths. Oxygen and hydrogen stable isotopes in groundwater can indicate elevation of recharge water, and sulfur stable isotopes in dissolved sulfate help distinguish the sulfur source-rock type. In many cases the ranges of  $\delta$ -values of possible sources of groundwater do not overlap, enabling unequivocal inference of groundwater sources and pathways. The stable isotopes indicate at least one previously unrecognized groundwater source plume and several groundwater mixing zones in the basin.

### H31B-0238 0830h POSTER

#### Moisture-dependent unsaturated stormflow in a semi-arid watershed, Boise, Idaho

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An experiment to describe streamflow generation and model the water budget under various semi-arid climatic conditions is ongoing in the Dry Creek basin, near Boise, Idaho. The coarse-grained soils and steep slopes of the region generate runoff primarily in the vadose zone, which extends over the entire soil profile above impermeable granite bedrock. The purpose of this paper is to document the control that soil moisture has on vadose zone runoff generation, and to present a simple model of runoff generation for dry soil conditions, wet soil conditions, and the transition between the two. Field observations suggest that when the wetting front is near the soil surface, lateral unsaturated subsurface flow is an important runoff generation mechanism in coarse-textured soils. With sufficient slope, infiltrated water travels laterally above the wetting front in wet soils of relatively high hydraulic conductivity at the expense of infiltrating into the lower conductivity dry soils below. As the wetting front advances in the soil profile, a transition in the hydrologic pathway occurs. Wet soils promote deep infiltration. Runoff generation then occurs when infiltrated water reaches an impermeable boundary then travels laterally to the stream margin. This moisture-dependent shift in flow mechanisms complicates contemporary modeling efforts.

### H31B-0239 0830h POSTER

#### The use of Streambed Temperature to Characterize the Spatial and Temporal Patterns of Ephemeral Streamflow in the Southwest

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Estimates of streamflow patterns in ephemeral channels are important in predicting the upper limits of potential recharge throughout the American Southwest. Quantitative information on the frequency and duration of ephemeral stream flows is often prohibitively difficult to obtain. Conventional streamgaging techniques and analysis tools are frequently unsuccessful in these stream channels, due to the flashy nature of the streamflows. In contrast, temperature has proven to be an inexpensive, robust parameter to measure in the field. The presence or absence of streamflow within the channel may be identified by studying the diurnal signal recorded at both the streambed surface and at depth because the presence of streamflow significantly alters these diurnal temperature patterns.

Longitudinal arrays of single channel recording thermistors were installed in three dry streambed channels in the American Southwest; Abo Arroyo and Isleta Arroyo, New Mexico, and the Amargosa River, Nevada,