H32I MCC: 3022 Wednesday 1600h

Watershed Processes and Linkages to Regional and Watershed Patterns in Stream Channel Morphology II

Presiding: **J M Faustini,** Oregon State University; **P R Kaufmann,** U.S. Environmental Protection Agency

H32I-01 1600h

Bedload Rating and Flow Competence Curves Vary With Watershed and Bed Material Parameters

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Bedload transport rating curves and flow competence curves (largest bedload size for specified flow) are usually not known for streams unless a large number of bedload samples has been collected and analyzed. However, this information is necessary for assessing instream flow needs and stream responses to watershed effects. This study therefore analyzed whether bedload transport rating and flow competence curves were related to stream parameters. Bedload transport rating curves and flow competence curves were obtained from extensive bedload sampling in six gravel- and cobble-bed mountain streams. Samples were collected using bedload traps and a large net sampler, both of which provide steep and relatively well-defined bedload rating and flow competence curves due to a long sampling duration, a large sampler opening and a large sampler capacity. The sampled streams have snowmelt regimes, steep (1-9%) gradients, and watersheds that are mainly forested and relatively undisturbed with basin area sizes of 8 to 105 km^2. The channels are slightly incised and can contain flows of more than 1.5 times bankfull with little overbank flow. Exponents of bedload rating and flow competence curves obtained from these measurements were found to systematically increase with basin area size and decrease with the degree of channel armoring. By contrast, coefficients of bedload rating and flow competence curves decreased with basin size and increased with armoring. All of these relationships were well-defined ($0.86 < r^2 < 0.99$). Data sets from other studies in coarse-bedded streams fit the indicated trend if the sampling device used allows measuring bedload transport rates over a wide range and if bedload supply is somewhat low. The existence of a general positive trend between bedload rating curve exponents and basin area, and a negative trend between coefficients and basin area, is confirmed by a large data set of bedload rating curves obtained from Helley-Smith samples. However, in this case, the trends only become visible as basin area sizes span a wide range (1 - 10,000 km^2). The well-defined relationships obtained from the bedload trap and the large net sampler suggest that exponents and coefficients of bedload transport rating curves (and flow competence curves) are predictable from an easily obtainable parameter such as basin size. However, the relationships of bedload rating curve exponents and coefficients with basin size and armoring appear to be influenced by the sampling device used and the watershed sediment production.

H32I-02 1615h

Spatial Variability in Surface and Subsurface Grain Sizes in a Meandering Gravel-Bed Stream

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Predictions of bed load transport in gravel streams with natural topography and curvature are complicated by spatial variations in the flow field and heterogeneities in the bed surface texture. Locally, differences in the ratio of surface to subsurface grain size, or degree of armoring, should reflect differences in the local transport rate for a given discharge and sediment supply, but in any reach these differences should balance in order to maintain equilibrium transport. Detailed measurements of bed topography, surface texture, and substrate sediment size were made in two gravel-bed reaches of the Colorado River in Rocky Mountain National Park in the summer of 2002. The data set for the upper site includes 95 surface pebble counts and 55 bulk samples of the substrate. The data set for the downstream site includes 73 surface pebble counts and 40 bulk samples of the substrate. Overall, the median grain size, D_{50}, of the bed surface at the upper site averages 23 mm, and the average D_{50} of the substrate is 12 mm. At the lower site the bed surface D_{50} averages 18 mm, and the average D_{50} of the substrate is 11 mm. Maps of the substrate illustrate that the subsurface grain sizes varied substantially through both bends, and local values appear to be related to the local surface grain sizes (r^2=0.44, $p<0.001$ and r^2=0.66, $p<0.001$ for upstream and downstream bends respectively). Ratios of surface to subsurface grain size were compared for regions greater than and less than the mean bankfull depth using a t-test. At the upstream site there were no significant differences in the degree of armoring between these two regions (p=0.68). However, at the downstream site the region with depths greater than bankfull was significantly less armored than the rest of the reach (p=0.01). Mapped values of the ratio of surface to substrate D_{50} for the upstream bend are irregular but nonetheless show that bed armoring is rather spatially uniform at the upstream crossing and bend apex. Downstream from the apex the region of low armoring is confined to a narrow band along the outside bank. Mapped values of bed armoring were much more systematic at the downstream site, implying that the spatial partitioning of bed load size fractions increases with reach radius of curvature. To test this hypothesis, nearly 190 coupled measurements of flow and sediment transport were made at the upstream site during the summer of 2003 at numerous locations within the bend. The majority of these measurements were made at flows greater than bankfull and several captured mobile gravel as large as 64mm. Preliminary results suggest that bed load sample bulk weights mirror the aforementioned pattern of armoring.

H32I-03 1630h

Bed Mobility on the Deschutes River, Oregon: Tracer Gravel Results

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The Deschutes River, drainage area 20,250 km2 near Madras , Oregon, is a gravel-bedded river, impounded since 1957 by three dams in the Pelton-Round Butte hydroelectric project, operated by Portland General Electric (PGE). Salmon spawning has declined in the reach below the dams since their construction, so possible project effects on spawning habitat are an issue of concern in relicensing of the project. Consultants to PGE applied the Parker bedload transport function to several sites below the hydroelectric dams; they concluded that the entrainment threshold flow was 340 m3s-1, and that the bed had been mobile only 25 days in the 72-year period of record from 1925-1996. However, their model was not calibrated with any actual field data of bed mobility or bedload transport, and the calculations were for full bed mobility, ignoring potentially significant bedload transport that might occur at a condition of partial mobility. To redress that lack of field data, we placed tracer gravels in the bed at three sites below the dams. In 2002 tracer gravels moved at one of the three sites after a flow of 150 m3s-1 (128-mm stones moved up to 1 m). The minor movement suggests that the bed is just beginning to move at 150 m3s-1, but indicates that the previously assumed entrainment threshold of 340 m3s-1 is too high.

H32I-04 1645h

A Sediment Budget Case Study: Comparing Watershed Scale Erosion Estimates to Modeled and Empirical Sediment Loads

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The Pacific Lumber Company Habitat Conservation Plan requires watershed analyses to be conducted on their property. This paper summarizes a portion of that analysis focusing on erosion and sedimentation processes and rates coupled with downstream sediment routing in the Freshwater Creek watershed in northwest California. Watershed scale erosion sources from hillslopes, roads, and channel banks were quantified using field surveys, aerial photo interpretation, and empirical modeling approaches for different elements of the study. Sediment transport rates for bedload were modeled, and sediment transport rates for suspended sediment were estimated based on size distribution of sediment inputs in relation to sizes transported in suspension. Recent short-term, high-quality estimates of suspended sediment yield that a community watershed group collected with technical assistance from the US Forest Service were used to validate the resulting sediment budget. Bedload yield data from an adjacent watershed, Jacoby Creek, provided another check on the sediment budget. The sediment budget techniques and bedload routing models used for this study generated sediment yield estimates that are in good agreement with available data. These results suggest that sediment budget techniques that require moderate levels of fieldwork can be used to provide relatively accurate technical assessments. Ongoing monitoring of sediment sources coupled with sediment routing models and reach scale field data allows for predictions to be made regarding in-channel sediment storage.

URL: http://www.oe-i.com

H32I-05 1700h

Investigating Linkages Between Watershed Scale Erosion and Reach Scale Channel Response

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The Pacific Lumber Company Habitat Conservation Plan generates both watershed-specific and generally applicable management practices (prescriptions) to reduce erosion and sedimentation rates. Watershed analyses produced under terms of the HCP include sediment budgets with detailed field measurements of in-stream sediment storage and a reach-scale sediment routing model. Monitoring of erosion, and stream channel conditions is being conducted to test the effectiveness of the erosion control prescriptions. As part of the monitoring process, a hypothesis was developed predicting changes in stored sediment in monitoring reaches resulting from predicted decreases in sediment inputs caused by management. Predicted changes in stored sediment were calculated based a range of assumptions regarding effectiveness of erosion control prescriptions over ten years. Long term monitoring of stored sediment in channels is being conducted to determine whether predicted changes in sediment inputs can be detected. Existing theory supports the hypotheses linking erosion processes with sediment routing and storage predictions. Potential limitations regarding measurement precision and statistical power are considered.

URL: http://www.oe-i.com

H32I-06 1715h

Analysis Of Multispectral Imagery And Modeling Contaminant Transport

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A significant concern in the monitoring of hazardous waste is the potential for contaminants to migrate into locations where their presence poses greater environmental risks. The transport modeling performed in this study demonstrates the joint use of remotely sensed multispectral imagery and mathematical modeling to assess the surface migration of contaminants. KINEROS, an event-driven model of surface runoff and sediment transport, was used to assess uranium transport for various rain events. While our specific application was uranium transport, the methods apply to surface transport of any substance of concern. The model inputs include parameters related to the size and slope of watershed components, vegetation, and soil conditions. One distinct set of model inputs was derived from remotely sensed imagery data and another from site-specific knowledge. To derive the parameters of the KINEROS model from remotely sensed data, classification analysis was performed on IKONOS four-band multispectral imagery of the watershed. A system known as GENIE, developed by Los Alamos National Laboratory, employs genetics algorithms to evolve classifiers based on small, user-selected training samples.

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The classification analysis derived by employing GENIE provided insight into the correct KINEROS parameters for various sub-elements of the watershed. The model results offer valuable information about portions of the watershed that contributed the most to contaminant transport. These methods are applicable to numerous sites where possible transport of waste materials or other hazardous substances poses an environmental risk. Consequently, the approach presented here is relevant to homeland security and emergency response scenarios, as well as long-term environmental monitoring applications. Because the approach rests on the analysis of remote sensing data, the techniques can be used to monitor a range of sites and can reduce costs of data collection for model calibration.

H32I-07 1730h

Watershed and mainstem river linkage on the Green River, Desolation and Gray Canyons, East-Central Utah

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Tributary watershed characteristics strongly influence mainstem river form in the relatively wild tributaries of the Green River where it flows through Desolation and Gray Canyons in east-central Utah. In the135-km study reach, 164 tributary drainage basins and their characteristics as well as various attributes and field measurements of the mainstem river valley and channel were analyzed in a GIS in order to determine the effects of watershed processes on mainstem channel form. Bedrock geology controls valley width at tributary junctions, thereby controlling the accommodation space available for the formation of alluvial fans found at tributary junctions. These fans form from debris and stream flows that occur in tributary watersheds. Fans serve as the link between tributary watershed processes and mainstem channel form. Fan-river linkage is defined by connectivity between tributary processes and the mainstem river through an incised channel and the presence of reworked gravel bars associated with fans. A wide variety of types of fans occur at tributary junctions exhibiting varying degrees of linkage with the Green River. Many tributaries do not affect mainstem processes at all, and exhibit little linkage with the river. Tributaries that are linked to river processes often have incised channels in their alluvial fans. These channels serve as a conduit for coarse material to reach the mainstem and create riffles and rapids. The degree of linkage with the mainstem river is most likely related to the types and frequencies of watershed processes occurring in tributary basins rather than drainage basin size. Gravel bars also frequently occur in reaches with active debris fans, and the presence or absence of debris flow processes in a watershed directly influences the overall gravel bar distribution and mainstem channel slope on this reach of the Green River.

H32I-08 1745h

A GIS Framework for Describing River Channel Bathymetry

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A geographic information system (GIS) approach for describing river channel bathymetry at regional-scale is presented. Based on the detailed bathymetry data collected for a reach along the Brazos River in Texas, a GIS framework for describing the channel bathymetry in three dimensions is developed. The framework inter-relates channel characteristics such as the meandering shape, the thalweg location, and the cross-sections with each other. Thus, by knowing only the meandering shape of the channel, it is possible to create a three-dimensional mesh that comprises a series of cross-sections and profile-lines (lines parallel to the flow). This approach is first applied to a short reach upstream of the study area to create a three-dimensional channel shape. Although the output does not reflect all the details that are typically observed with the river bathymetry, this approach provides a mean surface for the channel bed. The framework derived for the Brazos River is then modified to apply to two more reaches, namely the Guadalupe River and the Sulphur River in Texas, and the results are compared with the observed data.

H41A MCC: 3022 Thursday 0800h

Form, Process, and Climate in Landscape Evolution I

Presiding: **W E Dietrich,** University of California, Berkeley**; K Beven,** University of Lancaster

H41A-01 0800h INVITED

Process and Form in Holocene Landscapes: Modelling Human and Climatic Impacts

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Observations suggest that Mediterranean environments are significantly more sensitive to human impacts that to climate change through the Holocene period. However, many explanations of landscape change rest on interpretations of climatic variability that are difficult to sustain. Erosion and sedimentation data support an interpretation relating to local- (and later regional-) scale human modifications of the landscape with major and often irreversible impacts on the soil resource. For example, on the Causse de Gramat, SW France, erosion rates have varied significantly over distances of several kilometres under very similar geological, soil and climate conditions over the last 6,000 years. Despite the realization that human activity significantly modifies the erosional landscape in such settings, most work aiming at understanding these impacts has been very simplistic. The difficulty of estimating time-varying human impacts has commonly led to the use of relatively basic scenario-based models, particularly over the longer term. Scenario-based approaches suffer from two major problems. They are typically static, so that there is no feedback between the impact and its consequences, even though the latter might often lead to major behavioural modifications. Secondly, there is an element of circularity in the arguments used to generate scenarios for understanding past landform change, in that changes are known to have happened, so that scenarios big enough to produce them are often generated without considering the range of possible alternatives. The approach presented here draws on agent-based models to investigate human interactions with the landscape. Agent-based models use a "bottom-up" approach to the development of these interactions by investing decision-making capacities at the level of individuals, whose behaviour is constrained by the nature of the landscape itself and by interaction with other individuals within it. The model presented consists of four elements. First, a cellular landscape-evolution model characterizes erosion processes, soil development and sedimentation. Secondly, a plant-growth model allows the evolution of vegetated landscapes according to major plant functional types. Thirdly, animal activity within the landscape is simulated using an agent-based approach. Animals are simulated as agents, using cellular automata rules governed by underlying energetics. Fourthly, there are the human agents, simulated either using cellular automata, or using neural networks. Landscape evolution is simulated as the interaction of all four of these levels. Results presented will illustrate a number of key factors. The stability of animal and human populations within these landscapes is not a foregone conclusion, leading to quite different outcomes for similar initial conditions. The model can illustrate the potential for self-organization and the development of quite different sets of behavioural patterns. This approach is useful in the investigation of how well past human-landscape interactions are understood, and allows a contrast with explanations simply based on climate.

H41A-02 0815h

Erosion and Sedimentation in Response to Climate Change: a Numerical Study Using a Multiple Grain-size Sediment Transport Model

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This study investigates changes in the surface texture and slope of fluvial channels in response to an increase in fluvial discharge. We use a two grain-size (sand and gravel) sediment-transport model to calculate changes in surface texture through time. Initially, erosion of both grain sizes increases in the head waters, and a large flux of sediment is sent downstream. Below the areas of incision, gravel is deposited, while further downstream sand is deposited as well. During this period, network concavity is reduced. Eventually, the entire network begins to erode at a faster rate than the equilibrium rate (the rate of base-level lowering) and slopes throughout the drainage network become shallower than they would be at equilibrium. Even on the shallower slopes, erosion rates remain high because a large amount of gravel is eroded out of the channel and the surface remains fine. At later times, the channel surface coarsens and the channel slope increases again. All of these changes - decreasing and increasing slopes and coarsening and fining of the channel surface - result from a single increase in runoff across the landscape. The initial response in the network differs from the response at later times. The model predictions illustrate that there may not be a one-to-one relationship between climate change and the texture of alluvial deposits or transient channel slopes.

H41A-03 0830h

Climatic Controls on Hillslope Angles and Relief in the Himalayas

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Comparison of rainfall data with mean hillslope angles in the Himalayas show that hillslope angles decrease with an increase in mean annual rainfall where mean annual rainfall is greater than 2150 mm. Higher pore pressures and accelerated rates of chemical weathering in the wetter regions may decrease the threshold angle of hillslopes prone to landsliding. Holding valley spacing constant, the sensitivity of mean hillslope angle to climate implies that relief, in the absence of rock strength limits, is also dependent on climate. These results suggests that wet-to-dry climatic changes increase relief in regions with incising bedrock channels and dry-to-wet climatic changes reduce relief.

H41A-04 0845h

Hillslope morphology and sediment production modulated by fire in the Oregon Coast Range

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Since the 1970s, the Oregon Coast Range (OCR) has proven to be a fertile study area for testing, calibrating, and validating process-based models for sediment transport and production, but few of these studies have considered the influence of episodic fires, which were more prevalent during the Holocene and Late Pleistocene than today. Although recent conceptual models have considered the role of fire in regulating root reinforcement and the frequency of debris flows, geomorphic response at recent burn sites (1999, 2001, and 2003) suggests that the influence of fire may be far-reaching, affecting transport processes in areas not prone to debris flows. Although we observed sparse evidence for accelerated erosion by overland flow, unchanneled valleys in each of our study sites exhibited significant deposition due to dry ravel. At the 1999 burn site (Austa Fire), the pulse of accelerated transport has been sufficient to strip a significant portion of the soil mantle, leaving a series of ridges and valleys with a patchy soil cover. In addition, bedrock has been progressively emerging on steep sideslopes in the 2002 burn site (Siuslaw Fire). Similar to previous studies, the ravel response appears to result from the incineration and removal of understory vegetation (particularly ferns) that act as natural sediment traps. Using a series of artificial sediment traps, Bennett (M.S. thesis, OSU, 1982) quantified the effect of hillslope angle on post-fire, ravel-driven sediment flux. Our re-analysis of her data indicates that sediment flux increases non-linearly with slope angle and is well represented by a physically-based, nonlinear transport model previously tested and calibrated in the OCR (Roering et al., WRR, 1999). Importantly, model parameters calibrated for the post-fire dataset suggest that transport rates may increase by nearly an order of magnitude in the years following an intense burn. In addition, the critical gradient parameter, which governs the angle at