AGU Chapman Conference on Examining Ecohydrological Feedbacks of Landscape Change Along Elevation Gradients in Semiarid Regions

Boise and Sun Valley, Idaho, USA
4 – 8 October 2009

Conveners

- Bradford P. Wilcox, Texas A&M University, USA
- Mark S. Seyfried, Northwest Watershed Research Center, USA
- Jeffrey J. McDonnell, Oregon State University, USA
- Dave D. Breshears, University of Arizona, USA

Program Committee

- Amilcare Porporato, Duke University, USA
- Barbara Bond, Oregon State University, USA
- Brent Newman, Int. Atomic Energy Agency, USA
- Danny Marks, Northwest Watershed Research Center, USA
- David Williams, University of Wyoming, USA
- Derek Eamus, University of Technology, USA
- Enrique Vivoni, Arizona State University, USA
- John Wainwright, University of Sheffield, UK
- Kelly Caylor, Princeton University, USA
- Russell Scott, Southwest Watershed Res. Center, USA
- Travis Huxman, University of Arizona, USA

Financial Sponsors

The conference organizers wish to gratefully acknowledge the generous support of the following sponsors for their substantial student support for this conference.

University of Idaho

BASIN
Biogeosphere-Atmosphere Stable Isotope Network

NORTHWEST WATERSHED RESEARCH CENTER
USDA ARS
United States Department Of Agriculture
Agricultural Research Service

AGU Chapman Conference on Examining Ecohydrological Feedbacks of Landscape Change Along Elevation Gradients in Semiarid Regions
Boise and Sun Valley, Idaho, USA
4 – 8 October 2009

Meeting At A Glance

Conference Events – Boise, Idaho

Sunday, 4 October

1600h – 2000h	Conference Registration
1800h – 2000h	Meet & Greet Reception ♦ Aspen/Cedar Room The Grove Hotel, Boise, Idaho
2000h	Dinner on your own

Monday, 5 October 2009

0800h – 1800h	Conference Field Trip to Reynolds Creek
1830h – 2000h	Welcome Reception ♦ Aspen/Cedar Room
2000h	Dinner on your own

Conference Events – Sun Valley, Idaho

Tuesday, 6 October 2009

0830h – 1130h	Travel from Boise to Sun Valley
1200h – 1300h	Lunch
1300h – 1600h	Session I
1430h – 1500h	Afternoon Break
1700h – 18300h	Poster Session
1830h – 1930h	Keynote Speaker: Jeff Dozier
1930h – 2130h	Dinner

Wednesday, 7 October 2009

0700h – 0800h	Breakfast
0800h – 1100h	Session II
0930h – 1000h	Morning Break
1200h – 1300h	Lunch
1300h – 1600h	Free Time/Working Groups
1700h – 18300h	Poster Session
1830h – 1930h	Keynote Speaker: Jim Ehleringer
1930h – 2130h	Dinner

Thursday, 8 October 2009

0700h – 0800h	Breakfast
0800h – 1100h	Session III
0930h – 1000h	Morning Break
1200h – 1300h	Lunch
1300h – 1600h	Free Time/Working Groups
1700h – 18300h	Poster Session
1830h – 1930h	Keynote Speaker: Keith Smettem
1930h – 2130h	Dinner

Shuttle buses will depart from the Sun Valley Resort for the airport in Boise, Idaho on Friday 9 October at 0830h and 1200h.

Sun Valley Resort provides shuttle service daily to Friedman Memorial Airport in Hailey, Idaho. Please contact the resort directly to make your arrangements.

Scientific Program

Sunday, 4 October to Monday, 5 October – Boise, Idaho
The Meet and Greet Reception, Conference Field Trip, and Welcome Reception will take place at The Grove Hotel, Boise, Idaho. Registration will be located in the foyer near the Aspen/Cedar Room.

Tuesday, 6 October to Friday, 8 October – Sun Valley, Idaho
Sessions and events will take place at the Sun Valley Resort in Sun Valley, Idaho. For your convenience, the Registration/Information Desk will be located inside the Continental Room foyer throughout the conference.

SUNDAY, 4 OCTOBER 2009
THE GROVE HOTEL – BOISE

1800h–2000h **Aspen/Cedar Room**	Meet and Greet Reception & Opening Remarks
1600h–2000h **Foyer, Aspen/Cedar Room**	Conference Registration
2000h	Dinner on your own

MONDAY, 5 OCTOBER 2009
THE GROVE HOTEL - BOISE

0700h–0800h **Aspen/Cedar Room**	Continental Buffet Breakfast
0800h–1830h	Conference Field Trip to Reynolds Creek
1600h–2000h **Foyer, Aspen/Cedar Room**	Conference Registration
1830h–2000h **Aspen/Cedar Room**	Welcome Reception
2000h	Dinner on your own

TUESDAY, 6 OCTOBER 2009
THE GROVE HOTEL

0700h–0800h **Aspen/Cedar Room**	Continental Breakfast to Go (boxed breakfast is provided on the bus)
0830h–1130h	Travel from Boise to Sun Valley

TUESDAY, 6 OCTOBER 2009
SUN VALLEY RESORT

1200h–1300h **Lodge Dining Room**	Lunch at Sun Valley Resort
1300h–1600h **Continental Room**	**Session I: Connectivity Across Elevation Gradients** **Moderators: Bradford Wilcox, Dave D. Breshears**
1300h-1345h	**Chris Duffy,** The Pennsylvania State University "The Age of Recharge in Mountain-Front Flow Systems: A Dynamical Systems Approach"
1345h-1430h	**John Pomeroy,** University of Saskatchewan "Snow-Vegetation Interactions in Cold Regions Mountain Environments"
1430h-1500h	Afternoon Break
1500h-1545h	**Barbara Bond,** Oregon State University "Does Ecohydrological Connectivity Affect Sensitivity to Environmental Variability?"
1545h-1630h	**Greg Okin,** University of California, Los Angeles "Connectivity and Ecohydrological Feedbacks in Desertification"
1630h-1700h	**Juan Camilo Villegas,** University of Arizona "Evapotranspiration Partitioning Along Gradients of Tree Cover: Ecohydrological Insights from Experimental Evaluation in The Biosphere 2 Glasshouse Facility"
1715h–1830h **Limelight Salon B**	Poster Session
1830h–1930h **Continental Room**	**Jeff Dozier**, Keynote Speaker, University of California Santa Barbara "Living in the Water Environment: A Vision for Integrated Water Research"
1930h–2130h **Lodge Dining Room**	Dinner

WEDNESDAY, 7 OCTOBER 2009
SUN VALLEY RESORT

0700h–0800h **Continental Room**	Breakfast Buffet
0800h–1200h **Continental Room**	**Session II: Transformative Landscape Change from Lowlands to Highlands** **Moderators: Kelly Caylor, Jeff McDonnell**
0800h-0845h	**Travis Huxman,** University of Arizona "Understanding Evolving Ecohydrological Systems in Drylands"

0845h-0930h	**Craig Allen,** U.S. Geological Survey "Climate-induced Forest Die-off: Emerging Global Patterns and Ecohydrological Feedbacks"
0930h-1000h	Morning Break
1000h-1045h	**Todd Dawson,** University of California, Berkeley "Ecohydrological Consequences of Landscape Changes for California's Redwoods: Latitudinal Gradients as Proxies for Elevation, Precipitation and Future Climate Change"
1045h-1130h	**Marcus Weiler,** Universität Freiburg "On the Scaling of Snow Processes: Can Tiny Beetles Alter Watershed Hydrology?"
1130h-1200h	**Holly Bernard,** Young Professional, University of Wyoming "A Dual Isotope (13C and 18O) Approach to Infer Annual Aboveground Net Primary Production in Young Douglas-fir"
1200h–1300h **Lodge Dining Room**	Lunch
1300h–1800h	Free Time/Working Groups
1700h–1830h **Limelight Salon B**	Poster Session
1830h–1930h **Continental Room**	**Jim Ehleringer**, Keynote Speaker, University of Utah "Land-use Change Impacts Will Predominate Over Environmental Gradients in the Ecohydrology of Most Semi-arid Ecosystems"
1930h–2130h **Lodge Dining Room**	Dinner

THURSDAY, 8 OCTOBER 2009
SUN VALLEY RESORT

0700h–0800h **Continental Room**	Breakfast Buffet
0800h–1200h **Continental Room**	**Session III: Understanding Ecohydrological Linkages Across Scales** **Moderators: Mark Seyfried, Dave Williams**
0800h-0845h	**Danny Marks,** USDA Northwest Watershed Research Center "Integrated Observations and Hydrologic Modeling Over Snow-Dominated Mountain Basins"
0845h-0930h	**Derek Eamas,** University of Technology Sydney "Functional Convergence in Tree Water use Across Ecosystems: Results of a Comparative Study Using a Multiple Site Comparison and a Modified Jarvis-Stewart Model"

0930h-1000h	Morning Break
1000h–1045h	**Jayne Belnap,** U.S. Geological Survey “Eco” at the Local Scale Affects “Hydro” at the Regional Scale”
1045h-1130h	**Diane Pataki,** University of California, Irvine "Linking Ecology, Hydrology, and Decision-making in Semi-arid Cities"
1130h-1200h	**Trenton Franz,** Young Professional, Prediction of Regional Woody Species Distribution Patterns in the Drylands of the Central Kenyan Highland"
1200h–1300h **Lodge Dining Room**	Lunch
1300h–1800h	Free Time/Working Groups
1700h–1830h **Limelight Salon B**	Poster Session
1830h–1930h **Continental Room**	**Keith Smettem,** Keynote Speaker, University of Western Australia **“**Ecohydrological Trends Across a 1000mm Rainfall Gradient in Southwestern Australia”
1930h–2130h **Lodge Dining Room**	Dinner

POSTER SESSION SCHEDULE

Poster Session will be held in the Limelight Salon B, Tuesday, Wednesday, and Thursday from 1800h to 2000h.

TUESDAY, 6 OCTOBER 2009

Conveners: Danny Marks, Tony Parsons, and John Wainwright

TU101	**C.R. Ellis,** Sensitivity of Radiation to Snow in Rocky Mountain Coniferous Forests
TU102	**Richard Essery,** Improving Modeled Snowmelt Energetics in Semiarid Shrub Landscapes Through a Better Representation of Vegetation Characteristics
TU103	**Gerald Flerchinger,** Comparison of Energy and Carbon Fluxes of Sagebrush and Aspen Canopies within a Small Mountainous Catchment
TU104	**Peter Kirchner,** Snowmelt Processes in Southern Sierra Nevada Red Fir Forests
TU105	**Anna Liljedahl,** Evapotranspiration at an Arctic Coastal Desert Wetland, Barrow, Alaska
TU106	**Timothy Link,** A Sensitivity Study of Radiant Energy During Snowmelt in Non-Uniform Forests
TU107	**Danny Marks,** Integrated Observations and Hydrologic Modeling over Snow-Dominated Mountain Basins
TU108	**Neba Raj Neupane,** Quality Assessment, Reserve Estimation & Economic Analysis of Roofing Slate in the West Central Lesser Himalaya-Nepal
TU109	**Aaron Swallow,** Hydrologic Impacts of Vegetation Treatments Within Bates Creek Watershed, Wyoming
TU110	**Markus Weiler,** On the Scaling of Snow Processes: Can Tiny Beetles Alter Watershed Hydrology?
TU111	**Adam Winstral,** Modeling Wind Speed and Snow Accumulation Gradients Over Complex Terrain From Typically Collected Meteorological Data
TU112	**Peter Bíró,** Ecohydrological Feedback Dynamics at Grassland-Shrubland Transitions in New Mexico? A Modelling Approach
TU1113	**Shawn Brenner,** Hydrological Stores and Fluxes Along Elevation Gradients in the Dry Creek Watershed
TU114	**David D. Breshears,** Toward a More Holistic Perspective of Wind and Water Erosion Within Ecohydrology
TU115	**David Chandler,** Infiltrability Response to Vegetation and Fire Across a Sage-Steppe Catchment

TU116 **Amaury Frankl,** Analyzing Long-Term Gully Erosion Evolution and Environmental Change in North Ethiopia's Semi-Arid Mountains

TU117 **Joel Johnson,** Feedbacks Between Hydrology and Gully Headwall Erosion in a Discontinuous Arroyo Network, Southeast Arizona: Insights From Field Monitoring Using a Wireless Sensor Network

TU118 **Hanoch Lavee,** Ecogeomorphic Trends and Thresholds Along Climatic Transects

TU119 **Matthew Madsen,** Influence of Post-fire Soil Water Repellence and Simulated Rainfall Regimes on Revegetation Success

TU120 **Jan Nyssen,** Hydrological Response of Catchment Management in the North Ethiopian Highlands

TU121 **Sujith Ravi,** Resource Redistribution Patterns Induced by Rapid Vegetation Shifts and Their Impacts on Desertification

TU122 **Michele Reba,** A 25-year Dataset for Hydrologic Modeling from a Semiarid Research Watershed-Reynolds Creek Experimental Watershed

TU123 **Abraham Springer,** Role of Large-Scale Forest Restoration Treatments on the Ecohydrology of Semi-Arid Catchments

TU124 **Min-cheng Tu,** Runoff and Erosion Dynamics on Semi-arid Rangelands in Central Texas: Influence of Scale and Disturbance

TU125 **Laura Turnbull,** A Theoretical Approach to Urban Ecohydrology: Incorporating the Role of Humans as Engineers of Ecosystem Change

TU126 **John Wainwright,** Ecohydrological Interactions During Vegetation Change in the Southwestern USA

TU127 **Brad Wilcox,** Woody Plant Encroachment Paradox: Rivers Rebound as Degraded Grasslands Convert to Woodlands

TU128 **Willis Gwenzi,** Complex Temporal Dynamics of Vegetation in Water-limited Ecosystems Caused by Multiple Ecohydrological Feedbacks

WEDNESDAY, 7 OCTOBER 2009

Conveners: Russ Scott and Travis Huxman

WE101 **Robert Armstrong,** Differences in Growing Season Actual Evaporation Across Climatological Gradients Within the Canadian Prairie Agricultural Region

WE102 **Anna Tyler,** Effects of Annual and Ephemeral Plants on Carbon and Water Cycling in a Riparian Ecosystem and a Sonoran Desert Upland

WE103 **Ayodeji Arogundade,** Comparison Between Turbulent Fluxes Measured Over Burned and Unburned Sites of a Sagebrush-Dominated Mountain

WE104 **James Cleverly,** Ecohydrology of Groundwater-dependent, Semi-arid Riparian Ecosystems: Restoration, Fire, and Energetics

WE105 **Alejandro Flores,** Assimilation of Anticipated L-band Microwave Observations for Hillslope-scale Soil Moisture Estimation in Semiarid Landscapes: The Importance of Topography and Soils

WE106 **Ivan Geroy,** Factors Influencing Soil Moisture at the Hillslope Scale in a Semiarid Mountainous Environment.

WE107 **Christian Gunning,** Time-Frequency Visualization of Diel Riparian Groundwater Fluctuations Using Wavelets

WE108 **G. Darrel Jenerette,** Ecosystem Metabolism Along a 3000m Elevation Gradient in Southern California: Interactions Between Continuous Climate Gradients and Discrete Community Patches

WE109 **Mark Johnson,** Integrating Streamwater and Eddy Covariance-based Measurements of Carbon and Aater Fluxes for a Douglas-fir Headwater Catchment in Coastal British Columbia

WE110 **Kathleen Kavanagh,** Topographical Influences on Nocturnal Transpiration in Mountainous Forests

WE111 **John Kim,** Grassland Groundwater Resource and Carbon Storage Change With Cultivation and Woody Plant Invasion Across a Precipitation Gradient

WE112 **Darwin Law,** Water Use Efficiency of Gambel's Oak in a Semi-arid Ponderosa pine Forest: Partitioning Between Transpiration and PhotoSynthesis Changes Along Spatial and Temporal Gradients

WE113 **Gretchen Miller,** Upscaling Sap Flow: Observations From a Pilot Study and Implications for Transpiration Measurement Across a Gradient

WE114 **Frances O'Donnell,** Soil CO2 Fluxes Following Wetting Events: Field Observations and Modeling

WE115 **Luke Pangle,** Thresholds and Feedbacks Between Rainfall, Soil Moisture, Evapotranspiration, and Groundwater Recharge: A Microcosm Experiment

WE116 **Russ Scott,** Ecohydrological Consequences of Woody Plant Encroachment in Bottomland and Upland Locations of the Sonoran Desert

WE117 **Mark Seyfried,** Soil Water Content and Global Change Across an Elevation Gradient at Reynolds Creek, Idaho

WE118 **Toni Smith,** Using Soil Moisture Trends Across Topographic Gradients to Examine Controls on Ecosystem Dynamics in a Semi-arid Watershed

WE119 **Juan Camilo Villegas,** Evapotranspiration Partitioning Along Gradients of Tree Cover: Ecohydrological Insights From Experimental Evaluation In The Biosphere 2 Glasshouse Facility

WE120 **Michael Young,** Near-Surface Water Content and Carbon Flux in Biological Soil Crust

WE121 **Andrew Guswa,** Spatial Variability of Throughfall and Implications for Root Architecture

WE122 **Greg Barron-Gafford,** A Multiple-scale Analysis of Temperature and Precipitation as Controls over CO2 Fluxes Across a Vegetative Landscape Change Gradient in a Semiarid region

WE123 **Charlie Luce,** Declining Annual Streamflow Distributions in the Pacific Northwest United States, 1948-2006

WE124 **Chris Zou,** Woody Plant Encroachment and Water Cycle in Mesic Great Plain Grassland

WE125 **Jason Williams,** Hydrologic Impacts of Soil Water Repellency on Fine- to Coarse-Textured Soils of Wooded Shrublands and Shrub-Steppe Communities

WE126 **Alyson McDonald,** Understanding the Importance of Small Scale Hydrologic Variability to Successful River Management

WE127 **Dex Dean,** Rainfall and Runoff Dynamics of a Forested Coastal Wetland

THURSDAY, 8 OCTOBER 2009

Conveners: Enrique Vivoni and David Williams

TH101 **Henry Adams,** Rapid landscape Change Along Semiarid Elevation Gradients: Ecohydrological Drivers and Temperature Sensitivity of Drought-Triggered Tree Die-off

TH102 **Dave Bowling,** Carbon, Water, and Energy Fluxes of a Semiarid Utah Grassland During Multi-year Drought

TH103 **Sam Fernald,** Juniper Density Reduction Effects on Soil Moisture in Central New Mexico: Implications for Climate Thresholds of Water Availability

TH104 **Andrew Fox,** Linking Ecosystem Scale Vegetation Change to Shifts in Water and Carbon Cycling: the Consequences of Widespread Piñon Mortality in the Southwest

TH105 **Matthew Germino,** Feedback Relationships Between Plant Community Composition and Soil Hydrology: Results From a Aong-term Experimental Manipulation of amount and Timing of Precipitation in Cold desert of Idaho

TH106 **Stephen Good,** Modeling the Ecohydrology of Vegetation Succession Patters with Plant Functional Groups in Heterogeneous Landscapes

TH107 **Hugo Gutiérrez-Jurado,** Ecogeomorphic Expressions of an Aspect-controlled Semiarid Basin: Topographic Analyses with High Resolution Datasets

TH108 **B.C. Janzen,** Responses of Community Cover, Diversity, and Species Assemblages to Long-Term Changes to Seasonal Precipitation in Sagebrush Steppe Communities

TH109 **Marcy Litvak,** Determining the Sensitivity of New Mexico Biomes to Predicted Climate Change Scenarios of the Southwest

TH110 **Mike Poulos,** Microclimate Controls on Slope Angles in the Idaho Batholith

TH111 **Enrique Vivoni,** Catchment Patterns and Controls on Soil Moisture and Evapotranspiration in a Mountainous Basin within the North American Monsoon Region

TH112 **Christopher Watts,** Effects of latitudinal gradient in surface characteristics over the North American Monsoon Core Region

TH113 **Julie Finzel,** Long term Inter-annual Variability of Vegetation Production

TH114 **David Goodrich,** Ecological Valuation: A Framework for Applications in the Semiarid Southwest

TH115 **Douglas Baer,** Recent Advances in Field Instrumentation for Rapid Isotope Measurements of Water in Streams, Precipitation, Groundwater and Ambient Air

TH116 **Richard Brazier,** Carbon Loss due to 'Natural' Vegetation Change in Semi-arid Environments: Causes, Characteristics and Likely Implications

TH117 **Jessie Cable,** Ecohydrological Feedbacks in Subarctic and Arctic Ecosystems: Deep Soil Water Buffers Ecosystems From Climate Variability

TH118 **Priya Gupta,** Real-time Measurements of Water Vapor Isotopes Using Cavity Ring Down Spectroscopy: A Short Study of the Impact of Precipitation Gradients on Vegetation

TH119 **Cody Hale,** Discerning the Influence of Landscape Position on Forest-Stream Connections in Pacific Northwest Headwater Catchments

TH120 **Mukesh Kumar,** Exploring the Effects of Topography and Vegetation on Streamflow and Aquifer Response in a Mesoscale Watershed

TH121 **Chun-Ta Lai,** Water Isotope Ratios of Atmospheric Vapor in Forests: Effects of Air Entrainment and Rain Evaporation with Low Deuterium-Excess

TH122 **Jim McNamara,** Hydrological Stores and Fluxes Along Elevation Gradients in the Dry Creek Watershed

TH124 **Ziyong Sun,** Stable Hydrogen and Oxygen Isotopes in Precipitation in Linze, Northwestern China: Influence of Local Moisture Recycling and Secondary Evaporation

TH124 **Scott Tyler,** Headwater Catchments: Linking Aquatic Ecology, Hydrology and Habitat Recovery in a Changing Climate

TH125 **Lixin Wang,** Refining the Partitioning of Evapotranspiration as a Function of Woody Plant Cover Continuous Stable Isotope Monitoring Provides Bridge from Glasshouse to Field Conditions

TH126 **David Williams,** The Isotopic Signature of Water Vapor, Leaf Water and Transpiration in Mixed Conifer Forest

Rapid landscape Change Along Semiarid Elevation Gradients: Ecohydrological Drivers and Temperature Sensitivity of Drought-Triggered Tree Die-off

[*Henry D. Adams*] (Ecology & Evolutionary Biology and Biosphere 2, University of Arizona, Tucson AZ 85721, ph. 520-621-8220; fax 520-621-9190; e-mail: henry@email.arizona.edu); Darin J. Law (School of Natural Resources, University of Arizona, Tucson AZ 85721, ph. 520-626-7131; fax 520-621-8081; e-mail: dlaw@email.arizona.edu); David D. Breshears (School of Natural Resources, Ecology & Evolutionary Biology, and Biosphere 2, University of Arizona, Tucson AZ 85721, ph. 520-621-7259; fax 520-621-8081; e-mail: daveb@email.arizona.edu); Chris B. Zou (Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74077, ph. 405-744-9637; fax 405 744 3530, email: chris.zou@okstate.edu); Neil S. Cobb (Merriam-Powell Center for Environmental Research and Biological Sciences, Northern Arizona University, Flagstaff, AZ 86011, ph. 928-523-5528, fax 928-523-7500, email: neil.cobb@nau.edu); and Travis E. Huxman (Ecology & Evolutionary Biology and Biosphere 2, University of Arizona, Tucson AZ 85721, ph. 520-626-4092; fax 520-626-0793; e-mail: huxman@email.arizona.edu)

Environmental patterns and processes across semiarid landscapes in general and elevation gradients in particular reflect ecohydrological interactions between the components of the water budget and vegetation. These fundamental ecohydrological interactions are likely to be altered under projected changes in climate, which for many drylands include more frequent drought accompanied by warmer temperatures. One of the most rapid, extensive and fundamental ways in which vegetation patterns could be affected by climate change is through drought-induced tree mortality, yet major uncertainties exist regarding the ecohydrological drivers and temperature sensitivities of drought-induced tree mortality. Here we provide an overview of recent progress related to the ecohydrology of tree die-off. First, we note different ways in which mortality and other processes influence how vegetation patterns can shift along an elevation gradient. Second, we review non-mutually exclusive hypothesis about the mechanisms of drought-induced tree mortality, which include carbon starvation, hydraulic failure, and the effects of biotic agents (e.g. bark beetles). Third, we review recent and ongoing field observations and experiments focused on tree mortality. Specifically, we tested the hypothesis that warmer drought kills trees faster using the environmental controls of Biosphere 2. We placed transplanted piñon pines (Pinus edulis) in two areas of the glasshouse, one with temperatures close to ambient for the species, the other elevated by 4.3°C over ambient. We simulated severe drought on half of the trees in each area by restricting all precipitation or irrigation until they died. We also report on the progress of a complimentary field study in which trees have been transplanted lower in elevation as a surrogate for increased temperatures and have had water excluded to simulate drought.

Collectively these results highlight that vegetation patterns across semiarid landscapes and especially elevation gradients can change rapidly through drought-induced tree mortality. Notably, drought-induced tree mortality is highly sensitive to temperature, indicating that future changes in climate will likely trigger more frequent and extensive tree die-off. The experimental results indicate that the sensitivity to temperature is related to differences in respiration and therefore consistent with carbon starvation as a mechanism. Ongoing field studies will provide a bridge between glasshouse experiments and field observations to improve predictions of tree mortality. In summary, changes in climate and associated ecohydrological impacts to the water budget are projected to substantially increase drought-induced tree die-off across semiarid landscapes

and elevation gradients, and could in turn provide ecohydrological feedbacks to the water budget.

Climate-Induced Forest Die-off: Emerging Global Patterns and Ecohydrological Feedbacks

[*C D Allen*] (U.S. Geological Survey, Jemez Mountains Field Station, Los Alamos, NM 87544; ph. 505-672-3861 x541; fax 505-672-9607; e-mail: craig_allen@usgs.gov)

Ongoing climate changes are increasingly affecting the world's forests, which still cover ~30% of the global land surface. Although forest growth has improved in some regions due to greater growing season length and warmth (along with increased atmospheric CO2 or N), large growth declines or increased mortality from droughts or hotter temperatures are often observed where tree growth is strongly water-limited. These climate-driven increases in both chronic background tree mortality rates and episodes of rapid, broad-scale forest mortality are linked to elevated tree physiological stress, sometimes amplified by associated biotic agents (e.g., extensive bark beetle outbreaks in western North America). While drought-induced forest mortality is not a new phenomenon, with abundant historical examples, a current global synthesis of drought-induced forest mortality documents more than 150 studies since 1970 of forest mortality attributed to drought and/or heat; examples are presented from every wooded continent in forest types ranging from tropical moist forests and savannas to boreal forests. Given that anthropogenic climate change is projected to drive substantial increases in both mean temperatures and the frequency/duration/severity of extreme drought and heat in many regions, recent episodes of broad-scale drought-induced forest mortality may reflect increasing global risks of forest die-off, even in environments not normally considered water-limited. Since vegetation cover patterns are closely and interactively linked with ecosystem water fluxes, episodes of massive forest die-off can be expected to significantly affect ecohydrological patterns and processes, ranging from runoff and erosion to evaporation and transpiration. Diverse examples of such feedbacks between climate-induced forest mortality and ecohydrology are presented, from the Amazon Basin to detailed observations of linked changes in vegetation, runoff, and erosion in response to forest mortality in the southwestern US.

Differences in Growing Season Actual Evaporation Across Climatological Gradients Within the Canadian Prairie Agricultural Region

[*R N Armstrong*] (Centre for Hydrology, University of Saskatchewan, Saskatoon, SK S7N 5C8; ph. 306-966-1484; fax 306-966-1428; e-mail: robert.armstrong@usask.ca); J W Pomeroy (Centre for Hydrology, University of Saskatchewan, Saskatoon, SK S7N 5C8; ph. 306-966-1426; fax 306-966-1428; e-mail: john.pomeroy@usask.ca)

Seasonal actual evaporation over grass surfaces is highly variable across the range of semi-arid to sub-humid climates encountered in the agricultural belt of the Prairie Provinces of western Canada. This is due to differences in length of growing season, cumulative energy, aridity and available soil moisture in the region. Elevations rise from about 230 m at Winnipeg, Manitoba at the eastern edge to 1080 m in the foothills of western Alberta at Calgary. Growing season air temperatures decrease with increasing latitude, increasing elevation and from east to west. Growing season precipitation is highest at the edges of the region (Alberta 260 mm; Manitoba 290 mm) and lowest in the centre, (Saskatchewan 220 mm). The semi-arid region is centred on southern Alberta and parts of south-western Saskatchewan with the rest of the region classified as sub-humid.

The objective of this study is to examine the differences in seasonal actual evaporation for grassland across the

semi-arid to sub-humid transition. Analyses were performed over a 30 year record of growing seasons from eight stations, using the modular Cold Regions Hydrological Model (CRHM) platform. Within CRHM a combination evaporation model was coupled to a soil moisture accounting and runoff algorithm to estimate actual evaporation. Initial soil moisture conditions for each growing season were provided from provincial government observations or by modelling the infiltration to frozen soils from snowmelt. In conditions of adequate soil moisture the actual evaporation rate was found to be relatively insensitive to growing season climate. However, when soil moisture became low then evaporation rates dropped dramatically. As a result there was a strong sensitivity to the balance between length of growing season and seasonal precipitation. In the semi-arid zone and in drought years the length of growing season was longer but precipitation was smaller, the converse being true for the sub-humid zone and non-drought years. Consequently there is no consistent spatial gradient in actual evapotranspiration between semi-arid and sub-humid climates in this region, the trend varying with the cycle between drought and pluvial conditions.

Comparison Between Turbulent Fluxes Measured Over Burned and Unburned Sites of a Sagebrush-Dominated Mountain

[*A B Arogundade*] (Department of Bio and Agric Engineering, University of Idaho, Moscow, ID 83844-0904; ph. 208-596-3875; e-mail:arog5831@vandals.uidaho.edu); R.J Qualls (Department of Bio and Agric Engineering, University of Idaho, Moscow, ID 83844-0904; ph. 208-885-6184; e-mail:rqualls@uidaho.edu); W. Zhao (Kimberly Research & Extension Center, University of Idaho, 3793 N 3600 E, Kimberly, ID 83341; ph. 208-423-6669; e-mail-wzhao.ui@gmail.com)

Eddy covariance method of flux measurement was used to measure the turbulent fluxes of carbon dioxide, momentum, latent and sensible heat fluxes in burned (B) and unburned (UB) sites of a sagebrush-dominated mountain, and the results compared. The outcome of the investigation shows that fire altered the energy partitioning of radiant energy between latent and sensible heat fluxes. Radiation efficiency, sensible and latent heat fluxes were greater at the UB site while soil heat flux was greater at the B site. Mean daytime sensible heat fluxes at the UB and B sites were 131W/m2 and 118W/m2, respectively; while mean daytime latent heat fluxes at the unburned and burned sites were 70W/m2 and 58W/m2, correspondingly. Mean daily temperature was, however, lower at the UB site. On most of the days investigated, evapotranspiration (ET) was greater at the UB site except days with precipitation, during which the B site recorded higher amounts. Mean daily ET at the B site was 1.06mm/day while the corresponding value of ET at the UB site was 1.3mm/day. Cumulative ET for the period investigated were 54.47mm and 66.75mm for the B and UB sites, respectively. Average daytime Bowen ratios at the B and UB sites were 2.03 and 1.87, accordingly. Carbon dioxide flux at the UB site was almost twice the amount measured at the B site. Energy balance closure was better at the UB site; however, perfect closure was not achieved at both sites.

A Multiple-scale Analysis of Temperature and Precipitation as Controls over CO2 Fluxes Across a Vegetative Landscape Change Gradient in a Semiarid Region

[*G B Barron-Gafford*] (Ecology and Evolutionary Biology/B2 Earthscience, University of Arizona, Tucson, AZ 85721; ph. 520-548-0388; fax 520-621-9190; email: gregbg@email.arizona.edu); R S Scott (Southwest Watershed Research Center, USDA-ARS, 2000 E. Allen Rd., Tucson, AZ 85719; ph. 520-670-6380; fax 520-670-5550; e-mail: russ.scott@ars.usda.gov); G D Jenerette (Department of Botany & Plant Sciences, University of California-Riverside, Riverside, CA, 92521; ph. 951-827-7113; fax 951-827-4437; email: Darrel.Jenerette@ucr.edu); T E

Huxman (Biosphere 2, B2 Earthscience, Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ, 85721; ph. 520-626-4092; fax 520-626-0793; email: huxman@email.arizona.edu)

The physiognomic shift in ecosystem structure from a grassland to a woodland may alter the sensitivity of CO2 exchange of both the dominant plants and the entire ecosystem to variations in growing-season temperatures and precipitation inputs. Previous work has shown that deeper-rooting mesquite (Prosopis velutina) trees and shrubs have greater access to groundwater than bunchgrasses, and this access results in CO2 exchange becoming relatively decoupled from variations in monsoonal precipitation. We used a combination of leaf-level measures of gas exchange and ecosystem-level eddy covariance techniques to quantify alterations in ecosystem-scale feedbacks of carbon uptake and water exchange resulting from this vegetative landscape change. The responsiveness of grasslands and woodlands/savannas to changes in air temperatures and the onset of the dominant period of precipitation input allowed for the determination of when temperature-stress was driving plant/ecosystem responses and when it was not. Measurements were conducted prior to, during, and after the monsoon summer rain period. The importance of landscape position was examined by conducting simultaneous measurements within bottomland riparian and upland settings. Temperature optima were determined by fitting curves to net CO2 uptake data as a function of air temperature at both the leaf- and ecosystem scales. Responses of net CO2 exchange to inputs of monsoonal rainfall were found to depend on vegetation composition and the access of dominant plants to the water table. Our analysis revealed that the sites which have experienced the greatest level of woody encroachment are optimally suited for net CO2 assimilation within a relatively small "optima" range, but continue to assimilate high levels of CO2 throughout the growing season. This greater capacity for CO2 assimilation across a range of temperatures will likely have implications under projected patterns of climatic change for the semiarid southwest which include increased atmospheric temperature and altered precipitation patterns. The phreatophytic nature of these woody plants complicates our typical understandings of what type of plants (C3 versus C4) will best thrive under both of these predicted conditions.

Recent Advances in Field Instrumentation for Rapid Isotope Measurements of Water in Streams, Precipitation, Groundwater and Ambient Air

[*D S Baer*] (Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041-1529; ph. 650-965-7772; fax 650-965-7074; e-mail: d.baer@lgrinc.com); M Gupta (Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041-1529; ph. 650-965-7772; fax 650-965-7074; e-mail: m.gupta@lgrinc.com); E Berman (Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041-1529; ph. 650-965-7772; fax 650-965-7074; e-mail: e.berman@lgrinc.com); F Dong (Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041-1529; ph. 650-965-7772; fax 650-965-7074; e-mail: f.dong@lgrinc.com)

Time-resolved, high-precision measurements of δ2H and δ18O in liquid water samples can provide new information on the water flow paths, residence times in catchments, and groundwater migration. In addition, fast measurements of δ2H and δ18O in air can provide critical knowledge about the source, history and age of water supplies, and degree of water mixing. We present recent measurements in the field recorded by a Liquid Water Isotope Analyzer capable of quantifying isotopes of liquid water at a rate of 120 measurements per day. Measurements from multiple deployments will be presented including those from rain, snow and streams in the H. J. Andrews

Experimental Forest over 4 continuous weeks. In addition, measurements of water vapor isotopes in ambient air recorded at 2 Hz will be presented to demonstrate the ability for eddy covariance flux measurements and other applications that require fast time response in the field.

"Eco" at the Local Scale Affects "Hydro" at the Regional Scale

[J. Belnap] (US Geological Survey, Canyonlands Research Station, 2290 S. West Resource Blvd., Moab, UT 84532; ph. 435-719-2333; fax 435-719-2350; e-mail: jayne_belnap@usgs.gov); R. Reynolds (US Geological Survey, Box 25046, Denver, CO 80225-0046; ph. 303-236-1303; fax 303-236-5349; email: rreynolds@usgs.gov); M. Reheis (US Geological Survey, Box 25046, Denver, CO 80225-0046; ph. 303-236-1270; fax 303-236-1270; email: mreheis@usgs.gov); S. Phillips (US Geological Survey, Canyonlands Research Station, 2290 S. West Resource Blvd., Moab, UT 84532; ph. 435-719-2337; fax 435-719-2350; email: sue_phillips@usgs.gov); M. Miller (US Geological Survey, Colorado Plateau Research Station, 2255 N. Gemini Dr., Flagstaff, AZ 86001; ph. 435-644-4325; fax 435-644-4350; email: mark_miller@usgs.gov); F. Urban (US Geological Survey, Box 25046, Denver, CO 80225-0046; ph. 303-236-4790; fax 303-236-5349; email: furban@usgs.gov); H. Goldstein (US Geological Survey, Box 25046, Denver, CO 80225-0046; ph. 303-236-5506; fax 303-236-5349; email: hgoldstein@usgs.gov).

Dryland regions constitute over 35% of terrestrial global lands. Limited rainfall in these regions restricts plant growth and the spaces between vascular plants are often large. Most interspace soils are protected from erosion by the cover of rocks, physical crusts, and biological crusts (cyanobacteria, lichens, and mosses). However, disturbance of the soil surface in dryland regions (e.g. recreation, livestock, mining and energy explorations, military exercises, fire) generally reduces or eliminates the protective cover of the soils and leads to accelerated soil erosion. Wind tunnel data show that most desert surfaces produce little sediment under typical wind speeds. However, disturbed surfaces result in much higher sediment production from all surfaces tested, regardless of parent material, texture, or age of the soil surface. Future climate is predicted to be hotter and drier, and this will also reduce the cover of desert soil stabilizers and increasing vulnerability to soil erosion. Fire also destabilizes soil surfaces. Synergist effects, such as surface disturbance occurring during drought periods in annualized plant communities, can create very large dust events. As surface disturbance, invasion, fire, and drought are expected to increase in the future, increased dust production can be expected as well. This erosion results in lowered soil fertility at the dust source. At the sink, dust is deposited on nearby snowpack, darkening the snow and increasing melt rates. Increased melt rates significantly affect the quantity, quality, and timing of water in streams and rivers. As water becomes scarcer in the arid West, the production of dust associated with land use will likely become a major issue for land managers.

A Dual Isotope (13C and 18O) Approach to Infer Annual Aboveground Net Primary Production in Young Douglas-fir

[*H R Barnard*] (Department of Renewable Resources, University of Wyoming, Laramie, WY 82071-3354; ph. 307-766-2263; fax 307-766-6403; email: hrbarnard@yahoo.com); J R Brooks (Western Ecology Division, U.S. EPA/NHEERL, 200 SW 35th St., Corvallis, OR 97333; Ph. (541) 754-4684; fax (541) 754-4799; email: Brooks.ReneeJ@epa.gov); B J Bond (Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331; Ph. (541) 737-6110; fax (541) 737-1393; email: Barbara.Bond@oregonstate.edu)

While several studies have clearly shown that the isotopic composition of cellulose in tree rings (13Ccell and 18Ocell) can be a valuable source of information for the reconstruction of both, plant water relations and environmental variability, most investigations to date have been generally based on the analysis of either 13Ccell or 18Ocell, but only infrequently using both. Examination of inter-relationships between 13Ccell, 18Ocell, and tree ring width has the potential to illuminate new physiological information. Our specific objectives were to 1) to test the hypothesis that aboveground net primary production is equal to the product of the assimilation to stomatal conductance ratio (A/gs), derived from δ13Ccell and stomatal conductance (gs), derived from 18Ocell, 2) to examine how 13Ccell and 18Ocell responds to environmental variations with regard to crown dominance within a stand, and 3) to compare our observed values of 13Ccell and 18Ocell to a qualitative conceptual model of the 13C-18O relationship. We used natural environmental gradients in a steep catchment dominated by a single species to maximize variation in aboveground net primary production, while at the same time reducing the isotopic variation in source water and source CO2. Findings indicated that using both isotopes to interpret physiology appears to fit the expected temporal and spatial variation we observed. However, expanding the theory to predict relative rates of photosynthesis from isotopes does not conform to theory, potentially due to tree to tree differences in isotopic baselines. In addition, these isotopic estimates of photosynthesis did not match patterns of above ground productivity.

Ecohydrological Feedback Dynamics at Grassland-Shrubland Transitions in New Mexico? A Modelling Approach

[*P Bíró*] (Institute of Geoecology, University of Potsdam, 14476 Potsdam, Germany; ph. +49 331 977 2178; fax +49 331 977 2092; e- mail: peter.biro@uni-potsdam.de); E N Mueller (Institute of Geoecology, University of Potsdam, 14476 Potsdam, Germany; ph. +49 331 977 2975; fax +49 331 977 2092; e-mail: eva.mueller@uni- potsdam.de); J Wainwright (Department of Geography, University of Sheffield, Sheffield, S10 2TN, UK; ph. +44 114 222 7951; fax +44 114 279 7912; e-mail: j.wainwright@sheffield.ac.uk); L Turnbull (Global Institute of Sustainability, Arizona State University, Tempe, AZ 85287, USA; ph. +1 480 965 2975; fax +1 480 965 8087; e-mail: laura.turnbull@asu.edu)

The transformation of productive grassland to desert shrubland due to overgrazing by cattle has occurred for more than 100 years in the Chihuahuan Desert in New Mexico. Even when the livestock was removed, the degradation processes has been reported to continue. Overland flow generated by short, high-intensity convective rainstorm events has been suggested as having an important role in these land-degradation processes through the redistribution of water and soil resources.

To improve the understanding of the on-going degradation dynamics especially at the shrub-grass-transition zones, the focus of this study is on feedback mechanisms between vegetation dynamics, soil resources and hydrological transport processes. For this purpose, the spatially distributed hydrological transport model MAHLERAN that calculates water, sediment and nutrient (dissolved and attached) fluxes for individual high-intensity rainstorm events is being coupeled with the bio-geochemical model DAYCENT which accounts for the effects of nitrogen cycling on plant growth and soil-plant-atmosphere feedbacks across stable and unstable vegetation boundaries.

Besides collecting data for the parameterisation of the models, the development of field techniques for the estimation of the mass transfer coefficient describing the flux of dissolved nutrients from the upper soil layer into the overland flow and its quantification for different soils and vegetation types are two of the most important objectives on- site in New Mexico.

The poster will present a new hypothesis on how vegetation boundaries between grasslands and shrublands remain stable or grow to be unstable, a methodology for field-technique development and a scheme on how to use a coupled model system for both lateral transport processes and vertical vegetation dynamics to assess within- event and inter-event degradation processes.

Ecohydrological Controls on Land Surface Temperature Along Elevation Gradients

[*G. Bertoldi*] (Institute for Alpine Environment, EURAC research, Viale Druso 1, I-39100 Bolzano, Italy; ph. +39 0471 055 314; fax +39 0471 055 399; e-mail: giacomo.bertoldi@eurac.edu); C. Notarnicola (Institute for Alpine Environment, EURAC research); G. Leitinger (Institute for Alpine Environment, EURAC research; University of Innsbruck, Innsbruck, Austria); S. Della Chiesa (Institute for Alpine Environment, EURAC research); U. Tappeiner (Institute for Alpine Environment, EURAC research; University of Innsbruck, Innsbruck, Austria)

Mountain regions present extreme variability, due to elevation variations, patched land cover and vertically-structured ecosystems. This is reflected also by the Land Surface Temperature (LST) spatial distribution.

LST is a key parameter in the surface energy budget and it is controlled by the interplay of topography, radiation, atmospheric processes, soil moisture, land cover and vegetation types.In this contribution, the LST spatial distribution of an Alpine catchment is simulated by the eco-hydrological model GEOtop and compared with ground observations and a Landsat image in order to evaluate the relative importance of the different environmental factors. Results show that the major factors controlling LST spatial distribution are the incoming solar radiation and the land cover variability, with a distinct thermal behavior in north and south facing slopes.

The LST vertical gradient closely follows the air temperature in north facing slopes with little radiation, while in south facing slope the LST gradient appears to be controlled by the vegetation type.

In fact, both observations and simulations confirm the field evidence of a strong warming of Alpine low vegetation during sunny days. Soil moisture distribution exerts a minor control along mountain ridges and south exposed steep slopes.

Does Ecohydrological Connectivity Affect Sensitivity to Environmental Variability?

[*B J Bond*] (Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331; ph. 541-737-6110; fax 541-737-1393; e-mail: barbara.bond@oregonstate.edu); R B McKane (Western Ecology Division, Environmental Protection Agency, Corvallis, OR 97330; ph. 541-754-4631; e-mail: mckane.bob@epa.gov).

Our goal is to understand the influences of complex terrain on the sensitivity of carbon and water cycle processes to environmental drivers at different scales. Gravity-driven flowpaths of air and water transport material and energy across and through landscapes, creating connections can be either persistent or transient. From such complex interactions of structure and function, ecosystems may become self-organized, and emergent properties may arise at certain ranges of scale. This project is still in its early stages. The presentation will focus on the overall approach, empirical evidence suggesting connectivity at different time scales, and initial results from modeling.

Carbon, Water, and Energy Fluxes of a Semiarid Utah Grassland During Multi-year Drought

[*D R Bowling*] (Dept. of Biology, University of Utah, Salt Lake City, UT 84112-0820; ph. 801-581-2130; fax 801-581-2174; e-mail: bowling@biology.utah.edu); S Bethers (Dept. of Biology, University of Utah, Salt Lake City, UT 84112); C Lunch (Dept. of Biology, University of Utah, Salt Lake City, UT 84112, now at Marine Biological Laboratory, Woods Hole, MA 02543); E Grote (US Geological Survey, Southwest Biological Science Center, Moab, UT 84532) J Belnap (US Geological Survey, Southwest Biological Science Center, Moab, UT 84532)

The net exchange of carbon dioxide, water vapor, and energy were studied in a sparse semiarid grassland in southeast Utah for 5 years. The study began within a multi-year drought (5 consecutive years below the 40-yr mean of 203mm) and continued as the drought ended. Observed precipitation during the study years varied from 58 to 131 % of the long-term mean. Most available energy was converted to sensible heat; the Bowen ratio between rain events approached 100. The site is at the northern boundary of the influence of the North American Monsoon, which leads to small rain pulses during hot periods in summer. Following rain, peak latent heat flux was as large as 200 W/m2, but latent heat flux was usually much smaller, even during the most productive periods of the year. The grassland exhibited low net productivity compared to most other ecosystems, with peak carbon uptake in the spring of only 4 micromoles / m2 / s. Monsoon rains generally led to brief respiratory pulses in summer, lasting a few days at most, and never resulted in net carbon gain. Some carbon uptake was observed in fall following rain. The multi-year drought led to persistent deep soil drought. Spring carbon uptake at this site was regulated primarily by deep soil moisture during the spring, which depended strongly moisture recharge in the prior fall and winter. Our results provide a predictive basis for land managers to assess year-to-year variability in productivity of semiarid grasslands of the region.

Carbon Loss due to 'Natural' Vegetation Change in Semi-arid Environments: Causes, Characteristics and Likely Implications

[*Richard E. Brazier*] (Department of Geography, University of Exeter, AmoryBuilding, Rennes Drive, Exeter EX4 4RJ, UK; email: r.e.brazier@ex.ac.uk); Laura Turnbull (Global Institute of Sustainability, Arizona State University, PO Box 875402, Tempe, AZ 85287-5402; email: Laura.Turnbull@asu.edu); John Wainwright (Sheffield Centre for International Drylands Research, Department of Geography, University of Sheffield, Winter St, Sheffield S10 2TN, UK; email: j.wainwright@shef.ac.uk); Liz Dixon and Roland Bol (Cross Institute Programme for Sustainable Soil Function - SoilCIP - North Wyke Research Station, Okehampton, EX20 2SB, UK; email: roland.bol@bbsrc.ac.uk).

Monitoring contemporary erosion plots across a grass to shrub transition in the US south west, Turnbull et al. (submitted) found that as event rainfall increases, so does the proportion of runoff leaving each hillslope plot. Furthermore, as grass cover decreases and shrub cover increases across the transition, so the steepness of the relationship between runoff and rainfall increases. Higher runoff coefficients occur on shrub land than grassland. Furthermore, it was found that the total amount of erosion increased as runoff coefficients increased. More interestingly, it was also shown that total erosion increased across the transition from grass to shrub-covered plots, with the grass-dominated plots yielding a lower mass of sediment per unit of runoff than the shrub-dominated plots. Thus, it is hypothesised that net loss of carbon associated with runoff and erosion will also be fundamentally controlled by changing vegetation types. This paper draws together three lines of evidence which address this hypothesis,

namely contemporary monitoring of carbon fluxes in runoff waters, geospatial characterisation of carbon stores and depth profiles of carbon age and isotopic composition. Results show that although similar amounts of carbon may be stored in soils underlying different vegetation types, significantly more carbon is lost once a vegetation transition from grass to shrub occurs. In addition there is a progressive increase in carbon loss from pure grass end members to pure shrub end members, which on a landscape scale may well be both irreversible and potentially significant in terms of total global carbon fluxes.

References

Turnbull, L., Wainwright, J. and Brazier, R.E. (submitted) Hydrological and erosion responses to vegetation change: a transition from semi-arid grassland to shrubland. Hydrological Processes

Toward a More Holistic Perspective of Wind and Water Erosion Within Ecohydrology

[*David D. Breshears*] (School of Natural Resources, University of Arizona, Tucson, AZ 85721; ph. 520-626-7131; fax: 520-621-8081; email: daveb@email.arizona.edu); Jason P. Field (School of Natural Resources, University of Arizona, Tucson, AZ 85721; ph. 520-626-7131; fax: 520-621-8081; email: jpfield@email.arizona.edu); Jeffrey J. Whicker (Environmental Programs , Los Alamos National Laboratory, Los Alamos, NM 87545; ph. 505-667-2610; fax: 505-665-6071; email: jjwhicker@lanl.gov); Sujith Ravi (Biosphere 2, University of Arizona, Tucson, AZ 85721; ph (520) 626-0611; email: ravi@email.arizona.edu); Travis E. Huxman (Biosphere 2 and Department of Ecology and Evolutionary Biology, University of Arizona, Tucson AZ 85721; ph: 520-621-8220; huxman@email.arizona.edu); Paolo D'Odorico (University of Virginia, Charlottseville, VA 22904; ph: (434) 924-7241; email: paolo@virginia.edu)

Ecohydrology for semiarid regions in general and elevation gradients in particular focuses primarily on the interactions between vegetation and hydrological processes. However, a growing number of examples highlight ways in which ecological and hydrological processes are influenced also by aeolian processes. Here we (1) provide an overview of similarities, differences, and scale-dependencies associated with wind and water erosion; (2) highlight how the two processes can be compared and highlight responses to land management and global-change-type conditions, and (3) discuss associated implications for vegetation. In short, our goal is to increase awareness about the key roles that aeolian processes can play in influencing ecohydrology of semiarid regions in general and elevation gradients in particular.

Ecohydrological Feedbacks in Subarctic and Arctic Ecosystems: Deep Soil Water Buffers Ecosystems From Climate Variability

[*J M Cable*] (International Arctic Research Center, University of Alaska, Fairbanks, AK, 99775; ph. 907-474-2678; e-mail: jcable@iarc.uaf.edu); K Ogle (Departments of Botany and Statistics, University of Wyoming, Laramie, WY, 82071; ph. 307-766-3219; e-mail: kogle@uwyo.edu); J M Welker (Environmental and Natural Resources Institute, Biology Department, University of Alaska, Anchorage, AK, 99501; ph. 907-257-2701; e-mail: afjmw1@uaa.alaska.edu)

Ecohydrological feedbacks in arctic and subarctic landscapes are being altered through vegetation shifts and permafrost degradation, both of which are expected to affect evapotranspiration dynamics. Low precipitation and high vapor pressure deficits define much of the growing season period in arctic and subarctic areas in interior Alaska. However, low plant water stress and high vegetation cover relative to other semiarid ecosystems suggests that these ecosystems may rely on water sources other than seasonal precipitation. We hypothesized that (1) water originating at the seasonal thawing front in the soil is a consistent, deep water source that supports the water requirements of deeply rooted plants, (2) this "deep" source may be permafrost derived in systems with permafrost degradation, and (3) summer rainfall supports more shallowly rooted plants that use water from the near-surface soil. To test these hypotheses, we utilized stable isotopes and water flux measurements to evaluate plant water sources across a gradient in permafrost temperatures and different ecosystem types (i.e., black spruce to shrub tundra). The data were analyzed in a hierarchical Bayesian framework that coupled isotope mixing models with water flux models. The analyses revealed that in a dry year, plants consistently use deep water produced by a thawing active layer, and in some cases this was derived from degrading permafrost. In a wet year, however, plants use a mixture of rain water and thawing active layer water. Our findings suggest that ecohydrological feedbacks in arctic and subarctic ecosystems are linked to the consistent water sources deep in the active layer for plant use, resulting in a climatically buffered ecosystem. Moreover, most studies evaluating plant water sources and ecohydrological feedbacks in low-precipitation systems tend to focus on warm/hot arid or semiarid systems. Thus, this study provides a unique contribution by exploring such feedbacks in low-precipitation, cold ecosystems.

Infiltrability Response to Vegetation and Fire Across a Sage-Steppe Catchment

[*D G Chandler*] (Civil Engineering, Kansas State University, Manhattan, KS 66506; ph. 785-532-3123; fax 785-532-7717; email: dgc@ksu.edu); M S Seyfried (Northwest Watershed Research Center, USDA, Agricultural Research Service, 300 Park Blvd, Boise, Idaho 83712-7716; email: mseyfrie@nwrc.ars.usda.gov); M D Madsen (Dept. of Plant and Wildlife Sciences, 435 WIDB, Brigham Young University, Provo, Utah 84602; email: madsenemail@gmail.com)

Advancing understanding of scale and structure in hydrology is intrinsically linked to understating plant community controls on fluxes and stores of water. New knowledge is particularly important for semi arid environments, where soil water repellency is common and persistent. We surveyed unsaturated soil infiltrability and soil water repellency in aspen, big mountain sage and low sage in a semi-arid mountain catchment. Replicate measurements were made at 60 to 100 points along transects in each plant community before and after prescribed fire. Aspen did not burn. The large sample size supported development of statistical distributions for each treatment and comparison among treatments. The frequent violation of square root of time infiltration behavior in the big sage and aspen led us to compare the infiltration results in terms of polynomial curve constants, C1 and C2 as well as the derived terms K(h) and sorptivity, S, respectively. We found the form of early time behavior was generally as expected (positive C2) in low sage. In big sage and aspen we found infiltration rate increased with time (negative C2) at about half the measurement locations. This result is supported by the frequency of measurement points exhibiting soil water repellency in each treatment, before and after fire, but the two measures were not directly correlated. There were only slight differences in the distributions of C1 among treatments, indicating similar long term infiltration behavior, despite the observation of stonier soil in the low sage portion of the catchment. Fire did not significantly change the distribution of C1 and C2 in the sage treatments. This study highlights the advantage of extensive replicate measurements for assessing infiltration capacity and the need for new infiltration theory to represent increasing infiltration rate time series.

Ecohydrology of Groundwater-dependent, Semi-arid Riparian Ecosystems: Restoration, Fire, and Energetics

[*J R Cleverly*] (Department of Biology, MSC03 2020, 1 University of New

Mexico, Albuquerque, NM, 87131-0001; ph. 505-702-6837; fax 505-277-6318; e-mail: cleverly@sevilleta.unm.edu); J R Thibault (Department of Biology, MSC03 2020, 1 University

Riparian areas contain hotspots of ecological and hydrological activity. For the last ten years, the Rio-ET Lab at the University of New Mexico has maintained a network of eddy covariance and groundwater monitoring systems in riparian ecosystems to investigate ecohydrological feedbacks of landscape change to due climate fluctuations, ecosystem restoration, and fire. Along the Rio Grande in New Mexico, evapotranspiration from riparian areas exceeds precipitation by factor of 4:1 or more, and the excess demand is supplied by shallow groundwater. Groundwater originates from melted snowpack, accumulation of runoff from upper elevations, and municipal transfer of deep paleoaquifers. Fluctuations in climate and weather generate feedbacks between groundwater and vegetation in lower elevation riparian floodplains. For example, declining groundwater levels stimulate transpiration by dense saltcedar thickets, further driving the water table deeper. Energy balance from vegetated sites is dominated by latent heat flux (LE), and sensible heat flux (H) is often less than zero, indicating a preponderance in these ecosystems for evaporative cooling. Saltcedar ecosystems can be distinguished by their energy balance, which varies with drought status: dense, monospecific thickets are characterized by negligible or negative sensible heat flux while xeroriparian saltcedar thickets tend to be open with a average seasonal Bowen ratios ranging from 0.17 (wet year) to 0.64 (dry year). Forest fire had greatest effect on ecosystem energy balance by reducing daily peak latent heat flux from 450 to 300 W m-2 and eliminating evaporative cooling (H = 75 W m-2). Restoration of the pre-burned cottonwood forest was performed by removing the dense understory of non-native saltcedar and Russian olive. Energy balance responses to restoration were minimal, with a reduction in only LE to 400 W m-2, even though average seasonal Bowen ratio increased from -0.30 to -0.002. Water salvage was moderate but measurable, reducing seasonal ET rates to equal irrigated alfalfa, Russian olive and willow, and native cottonwood. In years when saltcedar was permitted to re-sprout from remaining root crowns, however, ET was even greater than before land use change was attempted. To successfully restore non-native saltcedar and Russian olive forests for the purpose of water salvage, care must be taken to identify the type of saltcedar ecosystem (xeroriparian or densely monospecific), to plan for revegetation or remaining vegetation, and to prevent revegetation by the target species.

Tree Root Profiles Along the Kalahari Rainfall Gradient

[*P D'Odorico*] (Department of Environmental Sciences, University of Virginia, Box 400123, Charlottesville VA, 22904; ph. 434-924-7241; e-mail: paolo@virginia.edu); G.S. Okin (Department of Geography, University of California, Los Angeles; e-mail: okin@ucla.edu); K K Caylor (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544; e-mail: kcaylor@princeton.edu); M. Tatlhego (Harry Oppenheimer Okavango Research Centre, University of Botswana; e-mail: gr8bionica@yahoo.com); F C O'Donnell (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544; e-mail: fodonnel@princeton.edu); D Perrot (Department of Geography, University of California, Los Angeles; e-mail: dperrot@ucla.edu); A Bhattachan (Department of Environmental Sciences, University of Virginia, Charlottesville VA, 22904; e-mail: ab2vb@virginia.edu).

Soil moisture is the environmental variable synthesizing the effect of climate, soil, and vegetation on the dynamics of water-limited plant ecosystems. In fact, the interaction between vegetation and soil moisture dynamics contributes to determine the composition and structure of dryland vegetation. Despite the important role of plant roots as mediators of vegetation-soil water interactions, patterns of root distribution remain a major unknown in the analysis of ecohydrological processes and of their dependence on hydrologic conditions. To investigate the hydroclimatic controls on plant root distribution, we focus on a segment of the Kalahari Transect (KT), across a relatively strong rainfall gradient (from ~600 mm/yr in the north to ~180 mm/yr in the south) on homogenous sandy soils. This region offers a unique experimental setting, which enables us to analyze the dependence of root morphology on rainfall regime without the confounding effects of soil heterogeneity. We interpret the results in the context of possible shifts in belowground biomass under changing climate/hydrological conditions.

Ecohydrological Consequences of Landscape Changes for California's Redwoods: Latitudinal Gradients as Proxies for Elevation, Precipitation and Future Climate Change

[*Todd Dawson*] (Departments of Integrative Biology and Environmental Science, Policy & Management, University of California – Berkeley, CA 94720; ph. 510-642-6090; fax 510-643-6264; e-mail: tdawson@berkeley.edu)

California's redwoods inhabit climate zones that are attitudinally narrow but latitudinally vast and are characterized by marked changes in climate, water balance and summertime drought. These same semi-arid zones have been subject to some of the most significant human-induced land-use and climate changes in California that have left their mark on the ecology and hydrology of both the coast redwood (Sequoia sempervirens) and giant sequoia (Sequoiadendron giganteum) ecosystems. For S. sempervirens the unique maritime climate, including the role of summertime fog, plays a pivotal role in shaping its ecohydrology at scales from leaves to landscapes. For S. giganteum the interplay between the severity of summer drought and the properties of the winter snowpack (depth, water content, period of development) set the boundaries on the ecohydrology and how it varies in space and in time. I will show plant-based, ecosystem-based and climate data from our ongoing investigations in both the coast redwood and giant sequoia forest ecosystems and discuss the consequences of our findings for the ecohydrology along the climate and precipitation gradients occupied by the Earth's tallest and largest trees.

Rainfall and Runoff Dynamics of a Forested Coastal Wetland

Dex D. Dean[1], Bradford Wilcox[1], John Jacob[2], Andy Sipocz[3], Clyde Munster[4]
[1]Ecosystem Science & Management – Texas A&M University. [2]Texas Coastal Watershed Program – Houston, Texas. [3]Texas Parks & Wildlife Department – San Jacinto, Texas. [4]Biological & Agricultural Engineering – Texas A&M University.

Hydrological processes in relatively flat coastal settings are sometimes much less transparent than in mountainous terrain, where processes are more clearly pronounced along steeper elevational gradients. As a result, wetland ecohydrologists and regulators are struggling to determine which freshwater wetlands should be regulated. The decision hinges on whether or not a significant hydrologic connection exists between the type of wetland in question and a navigable water body. It has never been more important to make accurate, fact-based decisions about freshwater wetland regulation. Rapid urbanization has created a need for expansion that is currently putting significant pressure on freshwater wetlands. In Texas alone, it has been estimated that 97,000 acres of forested wetlands along the Gulf Coast have been converted to other land uses since 1955, amid more substantial changes for other wetlands types. However, in the case of many freshwater wetlands, the prevailing assumption is that precipitation is primarily stored within the wetland with little or no surface connectivity to other bodies of water. The first step toward sound regulatory decisions is to evaluate the accuracy of this assumption by attempting to quantify wetland hydrologic process in situ. The purpose of this study is to document the surface hydrology of coastal forested wetlands. Rainfall and surface flow was monitored continuously since April 2005 for a coastal flatwoods wetland southeast of Houston, Texas. The study illustrates rainfall and runoff dynamics for very dry years, years with near average rainfall, and years with above average rainfall.

Living in the Water Environment: A Vision for Integrated Water Research

[J Dozier]University of California, Santa Barbara

Our task is to consider the infrastructure necessary to transform water research from single-discipline, local-scale inquiries to systematic predictions across multiple "water environments," defined by the combination of natural, engineered and socioeconomic attributes. The needs include new critical data, both directly measured and synthesized, and new tools to integrate these data among disciplines, across temporal and spatial scales, and under uncertainty, with the goal to address the most important water-related societal question: How can we sustain ecosystems and better manage and predict water availability and quality for future generations, given changes to the water cycle caused by human activities and climate trends? An integrated approach is crucial for understanding: (i) the effect of scale on integrated water technology and management strategies, (ii) similarities and differences among water environments and their effect on predictions, and (iii) the impact of institutions and human behavior on water.

The Age of Recharge in Mountain-Front Flow Systems: A Dynamical Systems Approach

[C Duff] Department of Civil & Environmental Engineering Penn State University

This research is developing a dynamical systems model for estimating recharge and the age of recharge across the climatic and topographic gradients of western mountains. An extensive literature has developed around the problem of direct simulation of tracer age distributions to diagnose transport in environmental systems. Theories have also been developed for estimation of tracer or isotope age in local and regional steady groundwater flow systems, and these approaches have been useful for making estimates of flow paths, flow rates, recharge, and time of travel for water resource assessment. The present paper explores theoretical and practical questions of how to interpret transient concentration-flow signals in terms of short term precipitation events and long term climate-time scale oscillations. The paper extends some earlier work (Duffy and Cusumano, WRR, 1998), where concentration-discharge phase-plane plots were shown to carry important time scales of both the flow and the environmental tracer inputs, in terms of direct simulation of "age" of water in a mountain-front setting. The dynamical model simulates the qualitative characteristics of climate, vegetation and hydrogeologic conditions. Discretization of the model is accomplished using the natural coordinates of the terrain (hypsometry). Explicit expressions are developed for transient mean age in the soil zone and recharge, and for groundwater flow across the mountain-front. Although the nonlinear dynamical model results are qualitative, the theory is easily extended to fully distributed models of concentration, age, and flow under transient conditions. The model is demonstrated for a mountain-front setting in central New Mexico, the Llano de Sandia and the Sevilleta LTER (Duffy, AGU Monograph, 2004, pp. 236-255). A simulation scenario explores the long range impacts of abrupt climate change on upland recharge and riparian evapotranspiration through gains and losses of groundwater to the Rio Grande.

Functional Convergence in Tree Water use Across Ecosystems: Results of a Comparative Study Using a Multiple Site Comparison and a Modified Jarvis-Stewart Model

[*D Eamus*] (University of Technology Sydney, PO Box 123, Broadway, NSW 2007 Australia; ph +66 2 9514 4154; fax +66 2 9514 4095; email: Derek.Eamus@uts.edu.au); R J Whitley (University of Technology Sydney, PO Box 123, Broadway, NSW 2007 Australia; fax +66 2 9514 4095; email: Rhys.j.Whitley@uts.edu.au); D Taylor (University of Technology Sydney, PO Box 123, Broadway, NSW 2007 Australia; fax +66 2 9514 4095; email: Daniel.Taylor@uts.edu.au); M Zeppel (University of Technology Sydney, PO Box 123, Broadway, NSW 2007 Australia; ph +66 2 9514 8405; fax +66 2 9514 4095; email: Melanie.Zeppel@uts.edu.au)

There is a great deal of evidence of functional convergence in hydraulic architecture across co-occurring species. Similarly there is much evidence showing functional convergence in the behaviour and regulation of processes such as photosynthesis and transpiration in co-occurring species. For example, Meinzer and co-workers has shown a common relationship between the maximum rate of sapwood-specific sapflux and stem diameter in a comparison of 31 species growing in a tropical moist forest in Panama, whilst Zeppel and co-workers show coordination in leaf area, sapwood area and canopy conductance in the regulation of tree water use. Similarly, functional convergence among co-occurring species in the response of stomatal conductance to vapour pressure deficit has been observed. There appear to be a limited number of physiological solutions to the problem of maximising carbon gain whilst minimising water loss. Coordination of stomatal and hydraulic properties (hydraulic architecture) appear to be commonly observed across species. There are strong evolutionary pressures to explain functional convergence in water use for co-occurring species. Most recently, Kelley and co-workers examined two contiguous ecosystems in northern Australia and observed functional convergence across these ecosystems. Such convergence across ecosystems was unexpected. In the present study, we further examine convergence across ecosystems using two methodologies. In the first we compare rates of water use as a function of tree size for eleven disparate sites differing in species composition. In this comparison we observed a single relationship despite large differences in rainfall and evaporative demand across sites. In the second method we use a simple yet effective model (a modified Jarvis-Stewart model) of stand water use and compare parameter values across ecosystems to answer the question: can a single set of parameter values adequately describe the patterns and rates of water use across multiple ecosystems? If the answer to this question is yes, we have strong support for the conclusion that even across ecosystems, there is a convergence of behaviours in the patterns and rates of water use by vegetation.

Sensitivity of Radiation to Snow in Rocky Mountain Coniferous Forests

[*C R Ellis*] (Centre for Hydrology, University of Saskatchewan, 117 Science Place, S7N 5C8, Canada; ph 306-966-5526; fax 306-966-1428; email cre152@mail.usask.ca;) J W Pomeroy (Centre for Hydrology, University of Saskatchewan, 117 Science Place, S7N 5C8, Canada; ph 306-966-1426; fax 306-966-1428; email john.pomeroy@usask.ca)

Coniferous forests cover much of the Rocky Mountain landscape from where snowmelt runoff is a critical water resource to Western North America. Energy for snowmelt in forests is dominated by radiation, which is strongly affected by forest cover through the extinction of shortwave radiation while simultaneously increasing longwave irradiance to snow via forest thermal emissions. Consequently, radiation to forest snow varies greatly with forest cover density and atmospheric condition, and is further complicated in mountain environments by the large ranges in slope, aspect and elevation. This study investigates the sensitivity of radiation to snow to changes in forest cover density, atmospheric condition, slope, aspect and elevation using a physically based model estimating shortwave and longwave fluxes to forest snow.

Particular attention is paid to the effect of longwave emissions from forests heated by shortwave radiation absorption. This feature is simulated by calculating the vertical distribution of shortwave absorption in the canopy and the probability of longwave emissions from heated foliage being transferred to sub-canopy snow. The model provides a useful representation of the widely varying shortwave and longwave radiation regimes observed on hillslopes of various grade and aspect and at differing elevations. Seasonal model simulations show that maximum cumulative radiation to snow occurs for very different forest cover densities on slopes of varying aspect, suggesting that the impact of changes in mountain forest cover on the timing and rate of snowmelt are strongly controlled by topography.

Juniper Density Reduction Effects on Soil Moisture in Central New Mexico: Implications for Climate Thresholds of Water Availability

[*A G Fernald] (Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003; ph. 575-646-1041; fax 575-646-5441; e-mail: fernald@nmsu.edu); F Gökbulak (Faculty of Forestry, Istanbul University, Bahçeköy 34473, Istanbul-Turkey; email: fgokbulak@istanbul.edu.tr); Hector R. Garduño (Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM, 88003; ph. 575-646-2515; fax 575-646-5441; e-mail: hrmzga@nmsu.edu).

In semi-arid regions of the western U.S. there is widespread interest in tree removal to increase streamflow, forage growth and groundwater recharge. Previous studies indicate no increased streamflow below 450 mm annual precipitation. Ongoing studies imply that below the threshold precipitation there may be groundwater recharge after tree thinning. We identified a location in central New Mexico with 325 mm annual precipitation to study water availability effects of treating juniper woodlands with herbicide. We hypothesized that treated stands would exhibit higher soil moisture due to reduced tree water demands and that interspaces would be warmer than under-canopy sites. In three distinct grazing exclosures, we instrumented treated and untreated trees with climate, soil moisture and surface temperature recording equipment. Study sites had similar precipitation patterns during the study with average weekly total rainfall of 7.99 mm. In keeping with our hypothesis, mean daily maximum surface soil temperature was highest (17.19 ºC) in interspaces, intermediate (16.13 ºC) under dead trees and lowest (14.90 º C) under live trees. Counter to our hypothesis, significant differences in surface soil moisture between treatments were found when soil was drier in treated than in untreated plots and when was there enough excess soil moisture (beyond surface vegetation needs) to wet the deepest soils. Interspace plots had less soil moisture than under tree plots. Treated plots had greater herbaceous vegetation production (55.26 kg.ha-1) than control plots (11.56 kg.ha-1). In this setting, most water gained by tree removal was apparently consumed by increased herbaceous vegetation, which is the main benefit of the tree thinning rangeland improvement. In addition to a precipitation threshold, there appears to be a mean annual potential evapotranspiration threshold above which water availability increases from tree thinning are limited.

Long term Inter-annual Variability of Vegetation Production

[J A Finzel] (Rangeland Ecology and Management, University of Idaho, Boise, ID 83712; ph 208-422-0722; fax 208-

334-1502; e-mail Julie@cgrass.com); M S Seyfried (USDA-ARS, Boise, ID, 83712; ph 208-4220715; fax 208-334-1503; e-mail: mark.seyfried@ars.usda.gov); M A Weltz (USDA-Agricultural Research Service Exotic and Invasive Weeds Research; 920 Reno, Nevada 89512; ph 775-784-6057; fax 775-784-1712; e-mail mark.weltz@ars.usda.gov); K Launchbaugh (Rangeland Ecology and Management, University of Idaho, ph (208) 885-4394; fax (208) 885-5190; e-mail KLAUNCHB@uidaho.edu)

It is well established that plant productivity in arid and semiarid regions is primarily limited by water availability and that inter-annual precipitation amounts are highly variable. It follows that plant productivity should also be highly variable in such environments. This variability is critical from at least two perspectives. First, optimal land management (e.g., livestock), is based on plant production. Second, carbon balance is directly related to plant production and therefore water availability. Direct measurement of either plant production or carbon dynamics is difficult and costly, so that it is unlikely that sufficient data will be collected to understand inter-annual variability. In an environment with little or no water loss to deep percolation or overland flow, soil water dynamics are indicative of plant water use and hence productivity. We use soil water data collected over 32 years to evaluate the accuracy of simulated soil water dynamics. Plant production is estimated from an index based on the assumption that production is a linear function of the ratio of actual to potential transpiration. We found reasonably good correspondence between measured and simulated water contents. Estimated production was highly variable and closely related to precipitation amount.

Comparison of Energy and Carbon Fluxes of Sagebrush and Aspen Canopies Within a Small Mountainous Catchment

[*Gerald N. Flerchinger*] (USDA Agricultural Research Service, Northwest Watershed Research Center, Boise, Idaho, ph. 208-422-0716, fax 208-334-1502, email: gerald.flerchinger@ars.usda.gov); Danny Marks (USDA Agricultural Research Service, Northwest Watershed Research Center, Boise, Idaho, ph. 208-422-0721, fax 208-334-1502, email: ars.danny@gmail.com); and Michele L. Reba ((USDA Agricultural Research Service, Northwest Watershed Research Center, Boise, Idaho, ph. 208-422-0727, fax 208-334-1502, email: Michele.reba@ars.usda.gov)

This study compares and contrasts the seasonal surface fluxes of sensible heat, latent heat and carbon measured over different vegetation in a rangeland mountainous environment within the Reynolds Creek Experimental Watershed. Eddy covariance systems were used to measure surface fluxes over sagebrush, aspen and the understory beneath the aspen canopy. Peak leaf area index of the sagebrush, aspen, and aspen understory was 0.8, 0.9, and 1.2, respectively. The sagebrush and aspen canopies were subject to similar meteorological forces, while the understory of the aspen was sheltered from the wind. Fluxes of latent heat and carbon for all sites were minimal through the winter. Growing season fluxes of latent heat and carbon were consistently higher above the aspen canopy than from the other sites. While growing season carbon fluxes were very similar for the sagebrush and aspen understory, latent heat fluxes for the sagebrush were consistently higher. Higher evapotranspiration from the sagebrush was likely because it is more exposed to the wind. Sensible heat flux from the aspen was very similar to that measured above the sagebrush, even though measured surface temperature of the sagebrush was consistently higher than that for the aspen canopy. Larger surface roughness of the aspen canopy apparently compensated for its lower surface temperature. Results from this study illustrate the influence of vegetation on the spatial variability of surface fluxes across rangeland landscapes.

Assimilation of Anticipated L-band Microwave Observations for Hillslope-scale Soil Moisture Estimation in Semiarid Landscapes: The Importance of Topography and Soils

[*A N Flores*] (Department of Geosciences, Boise State University, Boise, ID 83725-1535; ph. 208-426-2903; fax 208-426-4061; e-mail: lejoflores@boisestate.edu); D Entekhabi (Department of Civil and Environmental Engineering, MIT, Cambridge, MA 02139; ph. 617-253-9698; fax 617-258-8850; e-mail: darae@mit.edu); R L Bras (Henry Samueli School of Engineering, University of California at Irvine, Irvine, CA 92697-2700; ph. 949-824-6002; fax 949-824-7966; e-mail: rlbras@uci.edu)

Semiarid environments are are associated with significant spatiotemporal heterogeneity in soil moisture that is driven by factors affecting the redistribution of moisture across a range of scales. The ability to accurately estimate soil moisture at the scale of individual hillslopes (e.g., 10's to 100's of meters) would significantly advancing ecohydrological applications in semiarid lands such as landslide prediction, wildfire fuel load assessment, and flood forecasting. Planned soil moisture remote sensing platforms, particularly the National Aeronautic and Space Agency's Soil Moisture Active-Passive (SMAP) missions, will provide global observation of soil moisture in the lower microwave region at frequent revisit intervals (2-3 days) and are partly targeted at improving soil moisture knowledge for applications. Even at the proposed 1-3 km scale of SMAP radar observations, however, soil moisture products from this mission is too coarse in spatial resolution to capture hillslope-scale variation. Process ecohydrology models are capable of simulating soil moisture at the spatial scales required, but suffer from uncertainties in the input data, model parameters and structure. Through a set of synthetic experiments, we assess the degree to which data assimilation through the ensemble Kalman Filter can be used to fuse simulated L-band radar backscatter observations to uncertain hillslope-scale soil moisture estimates derived from a process ecohydrology model in the Walnut Gulch Experimental Watershed, Arizona. We demonstrate that in a semiarid environment, assimilation of microwave observations generally improves the forecast soil moisture distribution, particularly in the near surface environment. Representing the role of topography in controlling moisture redistribution, a measurement equation system that accounts for topographic impacts on observing geometry, and adequate characterization of uncertainty in soil hydraulic and thermal properties are critical to the success of a hillslope-scale soil moisture data assimilation system. This work suggests data assimilation is potentially useful for improving knowledge of soil moisture at hillslope scales, but also underscores the need for treatment of vegetation in process ecohydrology models and assimilation of additional in-situ observations where they are available.

Linking Ecosystem Scale Vegetation Change to Shifts in Water and Carbon Cycling: the Consequences of Widespread Piñon Mortality in the Southwest

[*A M Fox*] (Department of Biology, University of New Mexico, Albuquerque, NM, 87131-0001; ph. 505-277-8685; fax 505-277-0304; email: andyfox@unm.edu); M E Litvak (Department of Biology, University of New Mexico, Albuquerque, NM, 87131-0001; ph. 505-277-5580; fax 505-277-0304; email: mlitvak@unm.edu) N G McDowell (Earth and Environmental Sciences Division, Los Alamos National Laboratory, Los Alamos, NM 87545; ph. 505-665-2909; fax 505-665-3285; email: mcdowell@lanl.gov); T A Rahn (Earth and Environmental Sciences Division, Los Alamos National Laboratory, Los Alamos, NM 87545; ph. 505-667-1812; fax 505-665-3285; email: trahn@lanl.gov); M G Ryan (USDA Forest Service RMRS, Fort Collins, CO 80526; ph. 970-498-1012; fax 970-498-1012; email: mgryan@fs.fed.us); R L Sinsabaugh

(Department of Biology, University of New Mexico, Albuquerque, NM, 87131-0001; ph. 505-277-9043; fax 505-277-0304; email: rlsinsab@unm.edu)

Vegetation mortality is a widespread phenomenon in western North America and is expected to increase in response to future climate change. The consequences of such mortality on ecosystem water, carbon and energy fluxes and budgets are unknown, as are the mechanisms driving these consequences, because the needed experiments have not yet been conducted. We are undertaking these experiments by using eddy covariance towers and an accompanying suite of ecological and soil moisture measurements to monitor the consequences of mortality in piñon pine at (i) a control site which hasn't experienced recent extensive piñon death, (ii) a manipulation site where piñon greater than 10 cm diameter at breast height have been selectively killed over the flux footprint area and (iii) at a site which experienced extensive piñon mortality during a drought in 2002. This approach capitalizes on an existing chronosequence of mortality as well as experimental manipulations, allowing us to quantify existing patterns of mortality driven responses as well as test hypotheses regarding cause-and-effect mechanisms.

Our general hypothesis for the ecosystem scale water cycle is that pinon mortality will alter the vertical and horizontal pattern of infiltration of precipitation and the sources and patterns of water use by remaining small piñon, juniper, understory vegetation and surface evaporation. Pinon mortality may not significantly alter cumulative ecosystem evaportranspiration (ET), but associated changes in litter, bare soil fraction and replacement vegetation will likely alter the seasonal variation in the components, evaporation (E) and transpiration (T). Piñon mortality alters the ecosystem scale carbon cycle by shifting a large stock of carbon from productive biomass to detritus, leading to an initial decrease in net ecosystem production and an increase in carbon flux to the atmosphere. Because coarse woody debris is slow to decompose in semiarid environments we hypothesize that these sites will continue to be net carbon sources even after NPP recovers.

Here we present the results of our pre-treatment measurements which we use to establish the variability in water and carbon fluxes and budgets between our control and manipulation sites which will enable us to quantify the impacts of the piñon mortality. We show some preliminary data collected immediately following the manipulation that provides the first indication of the short term consequences of piñon mortality on the ecosystem scale water and carbon cycles.

Analyzing Long-Term Gully Erosion Evolution and Environmental Change in North Ethiopia?s Semi-Arid Mountains

A Frankl (Department of Geography, Ghent University, B-9000 Ghent, Belgium; ph. +03292644694; fax. +32092644985; e-mail: amaury.frankl@ugent.be); S De Mûelenaere (Department of Geography, Ghent University, B-9000 Ghent, Belgium; ph. +03292644694; fax. +32092644985; e-mail: stephanie.demuelenaere@ugent.be); E Meire (Department of Geography, Ghent University, B-9000 Ghent, Belgium; ph. +03292644694; fax. +32092644985; e-mail: ellen.meire@ugent.be); J Poesen (Physical and Regional Geography, K.U.Leuven, B-3000 Leuven, Belgium, ph. +3216326425; fax +3216322980; e-mail: jean.poesen@ees.kuleuven.be); M De Dapper (Department of Geography, Ghent University, B-9000 Ghent, Belgium; ph. +03292644690; fax. +32092644985; e-mail: morgan.dedapper@ugent.be); Mitiku Haile (Department of Land Resources Management and Environmental Protection, Mekelle University, Mekelle, Ethiopia; ph. +251344409228; fax +25134400793; e-mail: gualmitiku@yahoo.com); A De Wulf (Department of Geography, Ghent

University, B-9000 Ghent, Belgium; ph. +03292644687; fax. +32092644985; e-mail: alain.dewulf@ugent.be); J Deckers (Division Soil and Water Management, K.U.Leuven, B-3000 Leuven, Belgium; ph. +3216329742; fax +3216329760; e-mail: seppe.deckers@ees.kuleuven.be); [* J Nyssen *] (Department of Geography, Ghent University, B-9000 Ghent, Belgium; ph. +03292644653; fax. +32092644985; e-mail: jan.nyssen@ugent.be)

Severe gully erosion in the North Ethiopian highlands is linked to the vulnerability of the biophysical environment, rainfall intensity and variability and land use and cover (LUC) changes induced by high population pressure. Understanding trends in gully erosion, and the relation with changes in its triggers, is important to make sustainable development possible in semi-arid regions suffering from low food security and threatened by climatic deterioration.
Reconstructing long-term (1868-2009) patterns in gully erosion and environmental control, i.e. LUC changes and rainfall pattern changes, requires an extensive database of ground-based photographs (1868-1975), aerial photographs (1964-1992), satellite images (1972-2009), meteorological station data (1950s ? 2009) and field measurements. Quantifying gully erosion networks and volumes is done from an integrated analysis of historical ground-based photographs, aerial photographs and IKONOS imagery. Therefore, new methodologies are being developed based on fieldwork, digital photogrammetry and Geographic Information Science techniques.

LUC mapping and change analysis for periods prior to satellite imagery and aerial photography is done by developing a new methodology that georeferences LUC boundaries identified on historical photographs to the horizontal plane of the map. For the LANDSAT LUC analysis (1972-2000), images dated 1974-5 were calibrated using photographs of the same period. Therefore, a methodology was developed that involves the development of spectral signatures based on LUC observed on the photographs, and the recording of the location of those LUC units by GPS. Rainfall pattern changes will be analyzed from Rainfall Estimates (2001-2009) and meteorological station data. Early results show that gully erosion was already extensive in the late 19th century, caused by a largely degraded environment and that critical gully expansion occurred after the mid 20th century. Little care was given to land management in 1868 resulting in very low vegetation cover which depleted to a minimum in dry spells like in the 1980s. In recent decades land management practices result in an environmental recovery and decreasing gully erosion.

Prediction of Regional Woody Species Distribution Patterns in the Drylands of the Central Kenyan Highland

[*T E Franz*] (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544; ph. 609-258-7819; fax 609-259-1270; e-mail: tfranz@princeton.edu); K K Caylor (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544; ph. 609-258-4614; fax 609-259-2799; e-mail: kcaylor@princeton.edu)

Dryland ecosystem processes are governed by complex interactions between the atmosphere, soil, and vegetation that are tightly coupled through the mass balance of water. We present a quantitative ecohydrological framework for predicting regional species distribution patterns in dryland ecosystems. The framework is based on a model for the daily mass balance of water that represents the interactions between soils, climate, and vegetation. Woody species selection is based on the organization and optimization of dryland vegetation, which attempts to maximize water use while simultaneously minimizing stress over the growing season. We apply our model to the Upper Ewaso Ngrio river basin of the central Kenyan highlands in order to predict the distribution of four common Acacia species. Within the basin, the species are distributed across a 3000 m elevation gradient where mean annual precipitation decreases from 1000 on the slopes of Mt. Kenya to 450 mm at the basin outlet. Our results show that consideration of both water use and water stress avoidance is essential to generating the observed pattern of vegetation within the study basin. In addition, analysis of a 60-year basin-wide gage precipitation dataset reveals clear shifts in the frequency and intensity of storms with the same annual total. When we apply these changes within our optimization approach, we predict the upslope migration of two species, A. tortilis and A. xanthopholea to areas with higher mean annual rainfall driven by the more intense infrequent rain events. The model results suggest that ecohydrological models can be used to predict the impact of subtle changes in rainfall climatology that lead to large-scale shifts in dryland species distribution and abundance.

Feedback relationships between plant community composition and soil hydrology: results from a long-term experimental manipulation of amount and timing of precipitation in cold desert of Idaho

[*M Germino*] (Department of Biological Sciences, Idaho State University, Pocatello, ID, 83209; ph. 208-282-3285; fax 208-282-4570; e-mail: germmatt@isu.edu); L.J. Ingram (Faculty of Agriculture, Food and Natural Resources, The University of Sydney, Camden, NSW 2570 Australia; ph +61-2-9351-8800; fax: +61-2-9351-8875; e-mail: lingram@usyd.edu.au); B. Janzen (Department of Biological Sciences, Idaho State University, Pocatello, ID, 83209; ph. 208-569-9334; fax 208-282-4570; e-mail: janzbran@isu.edu)

Deserts worldwide are simultaneously experiencing shifts in vegetative land cover and in hydro-climate that will affect conveyance of meteoric waters to baseflow, climate feedbacks, wildfire, rangeland values, and other ecosystem services. We utilized a long-term experiment to determine how different precipitation regimes select for different vegetation types, and how vegetation types differ in their impact on soil hydrologic patterns. The experiment was originally designed to test "store-and-release" (or "evapotranspiration") cap designs for protecting buried waste in cold deserts, in sagebrush-steppe of the Idaho National Lab, USA. The experiment consists of 72 plots (n = 3) that are 8x8 m in areal extent by 2 m deep, and were constructed with either 1) native sagebrush-steppe vegetation or with monocultures of exotic and invasive crested wheatgrass, 2) ambient precipitation, or a doubling of precipitation in the dormant or in growing season, and 3) one of four soil types and depths. Plant cover and soil water content (VWC, neutron probe) measurements and the application of precipitation treatments have been conducted from 1993 to 2009. Not surprisingly, total community cover increased with supplemental precipitation but was otherwise surprisingly constant across treatments. Increases in canopy and biomass of sagebrush were particularly evident in plots that received irrigation in the winter dormant period and that had deeper soils. Ambient precipitation and shallower soils favored crested wheatgrass. Although the various experimental communities generally tended to remove most water inputs by mid-summer, rates of soil water depletion were greater in plots planted with a diverse mix of native species, particularly shrubs. Water content below community root zones (2 m depth) and corresponding estimates of hydraulic conductivity were rarely sufficient for appreciable baseflow to the aquifer. The few occasions of VWC increasing above field capacity at 2 m depth were mainly under the wheatgrass monocultures and in deeper soils, but hydraulic conductivity generally did not increase above a "good" flow rate of 0.001 cm/s on 99% of days in all treatments. Overall, our long-term findings reveal that ecohydrological properties such as precipitation:cover,

precipitation:evapotranspiration, and baseflow tendencies are fairly constant over the precipitation and soil water gradient we evaluated. The changes we did observe were in key plant population abundances and changes in plant community mainly affected rates of soil water depletion.

Factors Influencing Soil Moisture at the Hillslope Scale in a Semiarid Mountainous Environment.

[*I J Geroy*] (Department of Civil Engineering, Boise State University, Boise, ID 83725; ph. 208-426-5634; fax 208-426-4800; e-mail: ivangeroy@boisestate.edu); M M Gribb (Department of Civil Engineering, Boise State University, Boise, ID 83725; ph. 208-426-5707; fax 208-426-4800; e-mail: mgribb@boisestate.edu); J P McNamara (Department of Geosciences, Boise State University, Boise, ID 83725; ph. 208-426-1354; fax 208-426-4061; e-mail: jmcnamara@boisestate.edu); D G Chandler (Department of Civil Engineering, Kansas State University, Manhatten, KS 66506; ph. 785-532-3123; fax 785-532-7717; e-mail: dgc@ksu.edu)

Soil moisture serves as a boundary layer that couples ground, surface, and atmospheric water interactions via the processes of evapotranspiration, infiltration, and runoff generation. Consequently, knowledge of the spatial distribution of soil moisture has become increasingly important as water resource professionals seek to accurately quantify and understand the hydrologic cycle. While significant work has been completed comparing spatial trends of soil moisture to topographic variables in semiarid environments, less work has been done to quantify soil hydraulic properties and their relationships to spatial distribution patterns of soil moisture and topography. Soil hydraulic properties both affect and are affected by the geomorphologic, hydrologic, and ecologic processes occurring within a watershed. Here we present early results of an investigation into the spatial variations in soil hydraulic properties and their relationship to soil moisture distribution trends and topography at the hillslope scale in the Dry Creek Experimental Watershed (DCEW) near Boise, ID. A set of soil cores distributed in both elevation and aspect have been analyzed in the laboratory to describe soil water retention characteristics. Additionally, in-situ soil moisture and tensiometer measurements were completed during the late spring drydown near each soil core location. The timing of this monitoring allowed observation of the spatial distribution trends of soil moisture to be observed across the full range of soil moisture conditions that occur in the DCEW. Identifying spatial distribution trends of soil hydraulic properties, and the influence of these trends on soil moisture distribution patterns will allow for better understanding of watershed processes in the semiarid west.

Modeling the Ecohydrology of Vegetation Succession Patters With Plant Functional Groups in Heterogeneous Landscapes

[*S P Good*] (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544; ph. 609-227-1301; fax 609-258-2760; e-mail: sgood@princeton.edu); K K Caylor (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544; ph. 609-258-4614; fax 609-259-2799; e-mail: kcaylor@princeton.edu)

Successfully describing the coupled ecological and hydrological dynamics of vegetated landscapes requires consideration of interactions occurring at the individual level. While classic forest gap models can be used to predict the succession of specific species, these models require many simulations to arrive at statistically meaningful results. Alternatively, phytogeographic models relate vegetation biomes to climatology (among other factors), but do not include critical interactions that occur between individuals. We propose the use of vegetation functional groups as a means of representing the interactions between individual trees within a heterogenous landscape. This framework allows for the prediction of ecohydrological patterns arising from complex hydrological process, which we represent using a stochastic soil water balance that is modified according to the local topographic index in order to account for hillslope position within the watershed. Maximum evapotraspiration rates of individual trees are calculated by scaling leaf-level potential evapotranspiration estimated from the Penman-Moneith equation. The probability of all possible combinations of root water uptake and light availability are integrated across the landscape to determine expected vegetation growth rates. This method results in a tractable set of finite difference equations that describe the evolving structure and function of the simulated landscape. The model generates a suite of ecosystem variables useful for parameterizing global climate models. These include mean forest height, the vertical distribution of leaf area though the canopy, and fractional woody cover. In addition, the model quantitatively assesses landscape water allowing estimation of spatial variation in evapotranspiration and runoff/leakage as well as temporal shifts caused by successional vegetation change.

Ecological Valuation: A Framework for Applications in the Semiarid Southwest

[*D C Goodrich*] (USDA-ARS, Southwest Watershed Research Center, Tucson, AZ 85719; ph 520-670-6381 x 144; e-mail: dave.goodrich@ars.usda.gov), D S Brookshire (Univ. of New Mexico); J Thacher (Univ. of New Mexico), C D Broadbent (Univ. of New Mexico), M D Dixon (Univ. of South Dakota), L A Brand (Univ. of Arizona), K Benedict (Univ. of New Mexico), K Lansey (Univ. of Arizona), J C Stromberg (Arizona State Univ.); S Stewart (Univ. of Arizona) and M McIntosh (Attorney at Law and Bilingual Mediation and Facilitation, NM)

Quantifying the value of ecosystem or environmental services (e.g. water provisioning; food and fiber production; maintenance of habitat and biodiversity, etc.) is gaining significant interest among numerous natural resource management agencies and was recently formalized within the Federal government as part of the 2008 Farm Bill. This legislation directs the Secretary of Agriculture to establish science-based methods to measure the environmental benefits of conservation and land management in support of emerging environmental services (ES) markets. To facilitate this process, the government-wide Environmental Services Board (ESB) has been established with responsibility to guide and promote scientifically rigorous and economically sound methods for quantifying the various benefits of ecosystem services and set priorities for research on ES. The ESB is chaired by Secretary of Agriculture with membership of at least nine others, including Secretaries of Interior, Energy, and the Director of OSTP.

An overview of an interdisciplinary project to quantify the monetary value of traditionally non-market ecosystem services in the semi-arid San Pedro and Rio Grande riparian systems will be presented. Conservation of these and other freshwater riparian systems across the southwest is an issue of paramount importance. In these systems, groundwater, surface water and flood regimes strongly influence the abundance, composition, and structure of riparian vegetation, diversity and abundance of avian populations, and thus the overall quantity and quality of ecosystem services. For efforts to succeed in preserving these systems in light of climatic and anthropogenic changes, a stakeholder community and/or policy makers requires a clear understanding of the management options available and a mechanism to evaluate these options. One appropriate mechanism is a Decision Support System (DSS). For water management where ecosystem services are part of the decision-making criteria, a DSS should have the capability to evaluate management options through the use of a series of coupled physical and ecological models that generates ecosystems service outputs. These outputs can then be reflected as monetized societal values for purposes of analyzing management options. However, ecosystem service values generally remain unknown relative to market values for goods and services. It is the value of ecosystems services and how they are derived from a broad base of scientific information that is the primary focus of this presentation. A central tenant of our efforts is that ecosystems values are appropriately driven by sound scientific information and thus values and sound science are inextricably linked. In the absence of integrated science information, valuation studies (e.g. choice modeling and contingent valuation methods) typically rely on vague program descriptions and imperfect measures of the change in ecosystem services quality or quantity. A secondary focus of this paper is a discussion of the transferring of these values to other semi-arid areas. Finally, in the conclusion, we touch upon the issue of integration of these values back into a DSS for purposes of evaluating management options.

Time-Frequency Visualization of Diel Riparian Groundwater Fluctuations using Wavelets

[*C E Gunning*] (Department of Biology, University of New Mexico,Albuquerque, NM 87131; ph. 706-224-7627; fax 505-277-0304; email: xian@unm.edu)

Diel fluctuations of riparian groundwater resulting from phreatophyte evapotranspiration (PhET) can be easily observed in shallow, unconfined aquifers by means of inexpensive monitoring wells. The White method is the primary technique used to quantify PhET based on diel fluctuations. Major challenges to PhET quantification from the White method remain, and it is not as accurate as more direct methods, such as Eddy Covariance. Nonetheless, groundwater fluctuation data can reveal important temporal PhET trends, including the length and relative intensity of the growing season. Here, a continuous wavelet transform of the first time derivative (difference) of hourly groundwater level measurements was used to visualize diel variation for 6 wells over 3 years. The well sites presented here are all in the Middle Rio Grande bosque, whose groundwater system is closely coupled to a heavily-managed river with frequent perturbations. The sites considered vary from undisturbed cottonwood canopies with intact or removed understory vegetation to a recently burned cottonwood canopy that has suffered high mortality. As expected, the burned site shows very little diel variation. The remaining sites show a modest reduction in diel variation over the 3 years considered, with little variation in growing season between sites and years. This method is robust to non-diel variations in groundwater, and allows for rapid visual assessment of site ecohydrology, along with intrasite estimates of the length and intensity of each growing season. Intersite comparisons remain challenging without additional site-specific hydrological knowledge, particularly specific yield.

Real-time Measurements of Water Vapor Isotopes Using Cavity Ring Down Spectroscopy: A Short Study of the Impact of Precipitation Gradients on Vegetation

[*P Gupta*I Green*] (Picarro, Inc., 480 Oakmead Pkwy, Sunnyvale, CA 94085)

Stable isotopic analysis techniques have proven to be very valuable in establishing links between ecology and hydrology. This presentation demonstrates the application of a new isotopic water analyzer in making real-time measurements of water vapor isotopes to study the variation in precipitation. The isotopic measurements, and hence the precipitation gradients, can be linked to the amount of vegetation in the area. Such measurements of stable isotopes in water vapor are typically done with IRMS systems in core labs which precludes real-time field use. A new measurement technique, based on Cavity Ring Down Spectroscopy, has recently become available to enable high-throughput stable isotope ratio measurements in water. The instruments are small and portable enough so as to enable field use. The typical precision of this technique (<0.5 per mil for D and <0.1 per mil for 18O) is sufficient to allow reasonable conclusions to be drawn regarding the degree of change in isotopic ratio values across landscapes. By combining such measurements with powerful modeling and analysis techniques, the understanding of the spatial and temporal variations in water content, evaporation and percolation fluxes in terrestrial ecosystems can furthered. Such analysis will aid in understanding the complex interdependencies between ecological and hydrological processes and will provide critical information in refining existing models of water transport in ecosystems.

Spatial Variability of Throughfall and Implications for Root Architecture

[*Andrew J. Guswa*] (Picker Engineering Program, Smith College, Northampton, MA 01063; ph. 413-585-7019; fax 413-585-7001; email: aguswa@email.smith.edu)

Vegetation canopies intercept and redistribute precipitation in both space and time. While the correlation of the spatial distribution of throughfall with plant characteristics proves challenging, a number of studies have demonstrated that the spatial patterns are temporally persistent. This persistence produces wet and dry regions in the soil that may affect root architecture. Equating the marginal carbon cost and benefit of deeper roots enables the determination of a water-optimal root depth as a function of the stochastic nature of water inputs. Under this principle, the spatial variability in throughfall depth induced by the canopy leads to variability in root depth. The extensiveness of roots is quantified as the farthest reach of the root zone; intensiveness is quantified as the uniformity with which roots explore the soil. The degree to which roots are extensive versus intensive depends on the spatial distribution of throughfall along with vegetation, soil, and climate characteristics.

Topographic and Vegetation Feedbacks on the Ecogeomorphic and Radiation Properties of a Semiarid Basin with Contrasting Ecosystems

[*H A Gutiérrez-Jurado*] (Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM, 87801; ph. 575-835-5465; fax 575-835-6436; e-mail: hugo@nmt.edu); E R Vivoni (School of Earth and Space Exploration and School of Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ 85287-1404; ph. 480-965-5081; fax 480-965-8102; e-mail: vivoni@asu.edu)

Variations in vegetation structure and composition in aspect controlled semiarid basins of Central New Mexico promote fundamental differences in hydrogeomorphic processes on the hillslopes. We hypothesize that potential topographic-vegetation feedbacks exist and produce distinct eco-geomorphic signatures on hillslopes that can be quantified using terrain metrics and high resolution datasets. In this study, we investigate the role of vegetation on the topographic form of a semiarid basin with opposing slopes and vegetation patterns. Using three digital elevation models with sequentially improved resolution (IFSAR 10-m; dGPS 4-m, and; LiDAR 1-m) we derived a series of terrain and morphometric analyses to identify geomorphic descriptors related to observed differences in vegetation patterns in the study basin. The terrain analyses revealed statistically significant topographic and geomorphic differences in north and south facing hillslopes associated with vegetation contrasts. For example, we found that: (1) a more frequent hillslope diffusion erosion mechanism in mesic north facing ecosystems is caused by relatively higher slopes and: (2) a more frequent fluvial erosion mechanism in xeric south facing ecosystems is predominantly a result of larger contributing areas. Furthermore, using high resolution

LiDAR data we were able to find statistically different sediment transport regimes in north and south facing slopes due to different dominant factors. Improvements in the definition of ecogeomorphic properties points to the need for high resolution DEMs for assessing vegetation-hydrogeomorphic interactions at the catchment and hillslope scales.

Complex Temporal Dynamics of Vegetation in Water-limited Ecosystems Caused by Multiple Ecohydrological Feedbacks

[*W Gwenzi*] (Centre for Land Rehabilitation, School of Earth and Environment and School of Plant Biology, The University of Western Australia, WA 6009; ph: 61-8-64887346; fax: 61-8-64881050; e-mail: gwenzw01@student.uwa.edu.au); C. Hinz (Centre for Land Rehabilitation, School of Earth and Environment, The University of Western Australia, WA 6009); ph: 61-8-64883466; fax: 61-8-64881050; e-mail: christoph.hinz@.uwa.edu.au); G. McGrath (School of Earth and Environment, The University of Western Australia, WA 6009); ph: 61-8-64883735; fax: 61-8-64881050; e-mail: gavan.mcgrath@uwa.edu.au); E. Veneklaas (School of Plant Biology, The University of Western Australia, WA 6009; ph: 61-8-64883584; fax: 61-8-64881080; e-mail: evenekla@cyllene.uwa.edu.au); T.M. Bleby (School of Plant Biology, The University of Western Australia, WA 6009; ph: 61-8-64882073; e-mail: bleby@plants.uwa.edu.au

Ecohydrological feedbacks are considered key drivers of vegetation dynamics in water-limited environments. These feedbacks are responsible for the development of highly organized vegetation spatial patterns in water-limited ecosystems. However, few studies have investigated non-linear temporal dynamics in vegetation ecosystems. Based on a review of published empirical evidence, we propose a simple ecohydrological model that explicitly accounts for vegetation feedbacks on root water uptake, infiltration, bare soil evaporation, drainage and soil hydraulic properties, and soil moisture feedbacks on root birth and mortality. Using realistic model parameters with biophysical meanings, we investigated temporal patterns of vegetation arising from internal feedbacks, and the key parameters influencing such patterns. Preliminary results show a suite of model dynamics including monotonic transition towards equilibrium, and complex non-linear dynamics involving damped oscillations towards an equilibrium point (stable spiral) and sustained oscillations (limit cycles). Model dynamics was highly sensitive to parameters related to root growth, infiltration and bare soil evaporation. Contrary to previous studies where cyclic external forcing and explicit time delays were cited as sources of complex dynamics, our simple model demonstrates that internal feedbacks may induce biomass oscillation in water-limited ecosystems. Predicted dynamics are consistent with biomass overshooting observed on disturbed forested catchments and rehabilitated mine sites in water-limited ecosystems. A hypothesis based on soil moisture storage feedback on root growth is proposed as a plausible mechanism for biomass overshooting following disturbance. The implications of these theoretical results on restoration ecology, particularly the early development of ecosystems on rehabilitated mine sites will be highlighted.

Discerning the Influence of Landscape Position on Forest-Stream Connections in Pacific Northwest Headwater Catchments

[*V C Hale*] (Department of Forest Engineering, Resources, and Management, College of Forestry, Oregon State University, Corvallis, OR 97331; ph. 541-737-8811; fax 541-737-4316; email: cody.hale@oregonstate.edu); J J McDonnell (Department of Forest Engineering, Resources, and Management, College of Forestry, Oregon State University, Corvallis, OR

97331; ph. 541-737-8720; fax 541-737-4316; email: jeff.mcdonnell@oregonstate.edu)

The coupling of forest transpiration dynamics and diel streamflow suppression during growing season baseflow periods has long been observed in forested headwater catchments. However, the processes that link forest water use to the stream have yet to be elucidated. Here we present preliminary results of a new study at the Alsea watershed in the Oregon Coast Range where we attempt to establish a mechanistic understanding of ecohydrological coupling under low flow conditions. We take advantage of the very pronounced seasonality of the region, where rainfall is largely absent during the growing season. We combine physical, isotopic and forest manipulation approaches to address the question of how and where trees couple to hydrological pathways linked to low flow and diel flow changes. Pilot work in summer 2008 using sapflow sensors and flumes in sub-5 ha headwater catchments showed that only a limited zone of vegetation along the riparian corridor (within a few meters of either side of the stream channel) was necessary to account for measured diel streamflow suppression. We also found that the magnitude of streamflow suppression (as a percent of total daily discharge) increased with increasing catchment size (4% in a 2.5 ha, steep and highly incised sub-basin and 33% in a 70 ha catchment). In summer 2009 we removed trees along the riparian corridors of two gauged sub-5 ha catchments to test our hypotheses about vegetation-stream coupling from 2008. We present this diel suppression experiment and report on 18O and 2H mixing analysis of xylem water to that of soil water, groundwater, and stream water to track the water sources utilized by forest vegetation along two geomorphically different hillslope transects. While extremely preliminary and ongoing, our work is helping to provide a new mechanistic understanding of dry season forest-stream connections across a gradient of landscape positions and associated moisture conditions.

Responses of Community Cover, Diversity, and Species Assemblages to Long-Term Changes to Seasonal Precipitation in Sagebrush Steppe Communities

[*B C Janzen*] (Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007; ph. 208-569-9334; fax 208-282-4570; email: janzbran@isu.edu); M J Germino (Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007; ph 208-282-3285; fax 208-282-4570; email: germmatt@isu.edu)

Desert plant communities are strongly affected by seasonal patterns of precipitation and water availability, particularly in cold deserts where precipitation and suitable growing-season temperatures are uncoupled in time. Understanding how sagebrush steppe communities are affected by and respond to long-term increases in precipitation during either the growing or dormant season is essential to predicting vegetation responses to changes in precipitation patterns and ultimately how these responses impact the ecohydrology of the environment. We examined responses of plant cover, diversity, species assemblages, and transpiration rates in constructed sagebrush-steppe communities to a doubling of annual precipitation, applied either in the growing or dormant season over a ten-year period. Species assemblages, with respect to cover and diversity, were strongly affected by increased precipitation, regardless of seasonal application, but had little effect on species rank abundances. Species abundance distributions suggest that the diversity of the experimental communities results in part from functional differences among species. Hence, long-term alterations in precipitation patterns will potentially have a strong affect on the functional composition of sagebrush steppe communities, which will ultimately alter the ecohydrology of the local environment.

Ecosystem Metabolism Along a 3000m Elevation Gradient in Southern California: Interactions Between Continuous Climate Gradients and Discrete Community Patches

[G. Darrel Jenerette] (Department of Botany and Plant Sciences, University of California Riverside, Riverside, CA 92521; ph 951-214-0564; fax 951-827-4437; email: darrel.jenerette@ucr.edu); A Chatterjee ((Department of Botany and Plant Sciences, University of California Riverside, Riverside, CA 92521; ph 951-214-827-7113; fax 951-827-4437; email: amitavac@ucr.edu)

Elevation gradients are associated with both continuous changes in environmental drivers, such as precipitation and temperature, and non-linear changes in vegetation community composition. How these two sources of variability interact to affect overall ecosystem metabolism, water use, and the combined water use efficiency of multiple ecosystem properties is poorly understood. We have investigated the patterns of ecosystem metabolism along a 3000 meter elevation gradient in Southern California and couple observations to changes in both meteorology and vegetation community along this elevation gradient. Our analyses couple field measurements of organic matter pools and fluxes with linked ecosystem and hydrologic modeling to better understand the spatial patterns along this gradient. We extend this data-model comparison to better understand how combinations of climate gradients and vegetation community structure affects ecosystem metabolism.

Projections of future climate change suggest combined increases in temperature and decreases in soil moisture throughout this gradient. How these changes will affect ecosystem metabolism is a current focus of our research efforts.

Integrating Streamwater and Eddy Covariance-based Measurements of Carbon and Aater Fluxes for a Douglas-fir Headwater Catchment in Coastal British Columbia

[*M S Johnson*] (Institute for Resources, Environment and Sustainability and Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC V6T 1Z4; ph. 604-822-6919; fax 604-822-9250; e-mail: mark.johnson@ubc.ca); T A Black (Biometeorology and Soil Physics Group, University of British Columbia, Vancouver, BC V6T 1Z4; ph. 604-822-2730; e-mail: andrew.black@ubc.ca); R S Jassal (Biometeorology and Soil Physics Group, University of British Columbia, Vancouver, BC V6T 1Z4; ph. 604-822-9119; e-mail: rachhpal.jassal@ubc.ca)

Headwater systems exhibit the highest degree of terrestrial-aquatic connectivity of any spatial scale, yet evaluating interactions among vegetation, soil water and surface water remains an ongoing challenge in watershed-scale ecohydrology. We have begun a fully integrated study of carbon (C) and water fluxes for a coastal Douglas-fir watershed in southwestern BC. The study area has been the focus of biospheric-atmospheric exchange of CO2 and H2O using the eddy covariance (EC) technique for over 10 years. The footprint of the EC flux tower is spatially coincident with a 91 ha watershed and headwater stream draining the study area, exhibiting >80% overlap between the EC flux footprint and the watershed area. Streamwater export of C during the first year of the study totaled 5 g C per m2 of watershed area, with annual flow-weighted average concentrations of 0.97 mg C per L as dissolved CO2, 2.20 mg C per L as bicarbonate (dissolved organic carbon, DIC) and 3.35 mg C per L as dissolved organic carbon (DOC). Total streamwater export of dissolved C represents ~1% of the EC-measured net ecosystem productivity (NEP) for this near-end-of-rotation forest during the first year following fertilization (200 kg N per ha as urea) with NEP not accounting for C loss via CO2 evasion from the hydrosphere to the atmosphere. Continuing research is focused on biogeochemical "hot moments" represented in both terrestrial and aquatic components of the watershed.

Feedbacks Between Hydrology and Gully Headwall Erosion in a Discontinuous Arroyo Network, Southeast Arizona: Insights From Field Monitoring Using a Wireless Sensor Network

[*J P L Johnson*] (Jackson School of Geosciences, The University of Texas at Austin, Austin, TX 78713; ph. 617-251-5906; fax: 650-329-5299; email: joelj@jsg.utexas.edu); S B DeLong (U. S. Geological Survey, Menlo Park, CA 94025; ph. 650-329-5648; fax: 650-329-5299; email: sidelong@usgs.gov); K X Whipple (School of Earth and Space Exploration, University of Arizona, Tempe, AZ 85287; ph. 480-965-9508; fax: 480-965-8102; email: kxw@asu.edu); D Malmon (U. S. Geological Survey, Menlo Park, CA 94025; ph. 650-329-4934; fax: 650-329-5299; email: dmalmon@usgs.gov)

Rates and patterns of soil erosion in low-relief semiarid rangelands are controlled by complex and poorly understood feedbacks between hydrology, topography and vegetation. Through environmental monitoring, we have quantified relations between hydrology and soil headwall erosion at the transition from overland to channelized flow in a discontinuous arroyo network near Oracle, Arizona. Since June 2008 we have monitored rainfall, soil moisture, unchannelized surface runoff and channel discharge at 1-2 minute intervals, using more than 50 sensors attached to both conventional dataloggers and a custom-developed wireless sensor network. We compare and contrast the costs, benefits and reliability of the developing technology of wireless sensor networks and conventional monitoring solutions. In addition to local landscape hydrology, we measured soil erosion through repeat surveys using ground-based LiDAR, RTK GPS and time-lapse stereo photography. Between June 2008 and June 2009, gully headwalls in clay-rich, cohesive alluvial soil retreated up to 0.85 m. Headwall erosion occurred through multiple erosion mechanisms, each of which had different sensitivities to soil moisture content, wetting/drying, and direct runoff. Three key processes combined to cause headwall erosion while maintaining vertical headwall profiles: inter-event mass wasting from wetting and drying of clay-rich soils, grain and aggregate-scale erosion on headwall faces during runoff events, and plunge-pool erosion. Furthermore, the relative importance of these erosion mechanisms changed between the flash flood-dominated summer monsoonal season and lower-magnitude, longer-duration winter rainfall events. More than twice as much total rainfall occurred during the 2008 summer monsoon season (~280 mm) as occurred during winter rain and snow events (~130 mm). Measurable surface runoff only occurred during the summer monsoon, limiting plunge-pool erosion to the monsoon season. However, soil moisture increased during the winter months (likely due to greatly reduced evaporation rates), and wet-dry mass wasting was enhanced. Ecological factors also influence erosion and hydrology. A late 20th century woody plant invasion caused flow to be focused in vegetation-controlled microtopography, and also inhibited erosion through root reinforcement. In addition, patchy annual grasses prevail in low relief areas of overland flow, likely triggering a positive feedback by slowing flow and encouraging infiltration and flow expansion. Our data constrain feedbacks between the hydrology, ecology and erosion of semiarid landscapes, and may improve predictions of landscape responses to differing hydrological and climatic regimes.

Topographical Influences on Nocturnal Transpiration in Mountainous Forests

[*K L Kavanagh] (Forest Resources Department, University of Idaho, Moscow, ID 83844-1133; ph. 208-885-

2552; email: katyk@uidaho.edu); P Gag (Forest Resources Department, University of Idaho, Moscow, ID 83844-1133 petergag@vandals.uidaho.edu); R. Pangle (Forest Resources Department, University of Idaho, Moscow, ID 83844-1133; ph. 208-885-2552; email: rpangle@vandals.uidaho.edu)

It has been established that stomata are partially open during the night. Nocturnal stomatal conductance averages approximately 30% of maximum daylight stomatal conductance for several western conifer species. However, it is not known how much water is transpired from these partially open stomata during the night and how nocturnal transpiration varies with slope position. Cold air commonly pools in valley bottoms during the night so the trees on lower slopes experience a lower atmospheric vapor pressure deficit (D) relative to trees growing upslope. Therefore, we hypothesized that trees closer to valley bottom will have a lower rate of nocturnal transpiration relative to the upslope trees. To test this hypothesis we continuously measured whole-tree transpiration during the growing season on Douglas-fir trees along an elevational transect at the Mica Creek Experimental Watershed. Transpiration was measured using sapflux sensors. Probes were placed at DBH and the base of the live crown to distinguish sapflux caused by nocturnal refilling from nocturnal transpiration. To characterize the cold air pool at the research site we placed temperature sensors along an elevational transect from the valley bottom to ridgetop. The cold air pool formed on over 90% of the nights from June-September. The depth of the cold air pool was approximately 160m with the temperature at the bottom of the pool commonly 5-7oC cooler than the top of the pool. Nocturnal D averaged 0.8kPa and 0.5kPa in the tree canopy at the top and bottom our sapflux transect respectively. Nocturnal transpiration rates averaged 0.047mmolm-2s-1 (0.01SE), 0.043mmolm-2s-1 (0.006SE), and 0.022mmolm-2s-1 (0.004SE) for the high, middle and low elevation sites respectively. Overall, 6 to 29% of the 24hr transpirational water loss occurred at night depending on time of year and slope position. This study indicates that in the forested regions of central Idaho, nocturnal transpiration is a significant part of the water cycle and that nocturnal transpiration rates vary with slope position.

Grassland Groundwater Resource and Carbon Storage Change With Cultivation and Woody Plant Invasion Across a Precipitation Gradient

[*J H Kim*] (University Program of Ecology, Duke University, Durham, NC 27708; ph. 919-660-7290; fax 919-660-7293; e-mail: jhk11@duke.edu); E G Jobbágy (Grupo de estudios ambientales Universidad Nacional de San Luis, Ejercito de los Andes 950 1er Piso, San Luis, SL D5700HHW, Argentina; ph. 54-2652-424740; e-mail: jobbagy@unsl.edu.ar); R B Jackson (Nicholas School of the Environment Department of Biology Duke University, PO Box 90338, Durham, NC 27708; ph. 919-660-7408; fax 919-660-7293; e-mail: jackson@duke.edu)

Land-use/cover changes affect flux and storages of ecosystem water and carbon, which are becoming increasingly important in light of projected global water shortages and climate change. Water provision and carbon sequestration are two important ecosystem services from natural and human-managed systems for sustainability of these systems. Cultivation of food crops and woody-plant invasion are prevalent land-use changes in grasslands. We compared belowground water flux and total ecosystem carbon storage in adjacent stands of natural grasslands (G), woody-invaded (W), and cultivated plots (C). Sites were located in 6 sites across a precipitation gradient in the Pampa grasslands of Argentina. Soil samples were excavated to 9 meters or to groundwater level and analyzed for chloride to estimate groundwater recharge rates using the chloride mass balance approach. Cores were also analyzed for soil organic and inorganic carbon. Standing biomass were measured by harvesting and allometric equations. Comparison of soil chloride profiles under the land-use/cover change from the grasslands suggested reduced groundwater recharge and higher water use under woody plants but enhanced recharge under cultivation compared to the grasslands. The estimated recharge rates increased with precipitation, and the differences between G-W decreased while the differences between G-C increased with precipitation. Soil organic carbon stock was higher in woody plants compared to grasslands in dry sites (70%), but was lower in wetter sites (-20%). Total carbon gain for woody plant invasion was positive from large gain in biomass. Cultivated plots always had lower soil organic carbon compared to grasslands (-5 to -40%). These results indicate that ecosystem carbon gain comes at a cost of water loss by evapotranspiration for woody plant invasion and vice-versa for cultivation. Coupling these measurements to valuation of the ecosystem services will help determine the optimum land-use/cover under global environmental changes.

Snowmelt Processes in Southern Sierra Nevada Red Fir Forests

[P Kirchner] Sierra Nevada Research Institute, University of California, Merced; ph (209) 834-7628; fax 228-4047; e-mail pkirchner@ucmerced.edu; Roger Bales Sierra Nevada Research Institute University of California, Merced; ph (209) 228-4348;
fax 228-4047; e-mail rbales@ucmerced.edu

Snow distributions and melt in montaine forests are highly variable in time and space. We present results from a forested catchment in Sequoia National Park in the Sierra Nevada mountains of California. We examine the heterogeneity of snow distribution and melt timing at both plot and stand scales. Synoptic snow surveys of over 200 locations in a red fir stand were conducted within 1 week of April 1st 2007-2009. Coincidental snow depth, soil temperature and soil moisture measurements were instrumentally recorded at 7 locations within the stand. An additional 24 temperature measurements were made on two 10 x 10m plots around individual trees in 2009. These data show, at the stand scale, snow water equivalent is approximately 35% less 1m from the tree stems than in adjacent open areas at the time of the surveys and, at plot scales, the timing of snowmelt can vary up to 45 days around a single tree. Additionally stand surveys demonstrate stationary melt patterns from year to year despite significant differences in total snow accumulation and melt timing. Modeled radiation of the stand indicates a decoupling with snowmelt suggesting canopy structure is an important determinant of snowmelt patterns in this catchment.

Exploring the Effects of Topography and Vegetation on Streamflow and Aquifer Response in a Mesoscale Watershed

[*M Kumar*] (Department of Civil Engg., Pennstate University, email: muk139@psu.edu); G Bhatt (gxb913@psu.edu) and C J Duffy (cxd11@psu.edu) (Department of Civil Engg., Pennstate University)

Understanding and predicting of flow on the surface and in the subsurface necessitates recognizing that surface water, plant water, soil and groundwater, and the atmosphere are linked components of a hydrologic continuum. In order to capture the interaction between different components of a hydrologic continuum at multiple spatio-temporal scales, full coupling of physical processes, natural numerical coupling, and parsimonious but accurate data coupling is needed. Here we use a physically-based, spatially distributed hydrologic model (called PIHM) to simulate interception, snow melt, transpiration, evaporation, overland flow, subsurface flow, river flow, macropore based infiltration and lateral stormflow, as well as flow through and over hydraulic structures such as weirs and dams, in a mesoscale watershed in central PA (Little-Juniata Watershed, 845 km2). Using the fully-coupled model, we explore a range of multiscale/multiprocess interactions including: 1) an apparent inverse relationship between fraction of total evapotranspiration rate due to transpiration and interception loss, 2) the role of forcing (precipitation, temperature and radiation), soil moisture and overland flow on evaporation-transpiration partitioning, 3) the importance of water table depth on evaporation-transpiration, 4) the influence of local upland topography and stream morphology on spatially distributed, asymmetric right-left bank river-aquifer interactions, and, 5) the role of macropore and topography on ground water recharge magnitude, time scale and spatial distribution.

Water Isotope Ratios of Atmospheric Vapor in Forests: Effects of Air Entrainment and Rain Evaporation with Low Deuterium-Excess

[*Chun-Ta Lai*] (Department of Biology, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182, USA; ph. 619-594-0678; fax. 619-594-5676; email: lai@sciences.sdsu.edu); James R. Ehleringer (Department of Biology, University of Utah, 257S 1400E, Salt Lake City, UT 84112-0840, USA; ph. 801-581-7623; fax. 801-81-4665; email: ehleringer@biology.sdsu.edu)

An understanding of atmospheric water vapor content and its isotopic composition is important if we are to be able to model future water vapor dynamics and its potential feedbacks on future climate change. Here we present diurnal and vertical patterns of water isotope ratios in forest air not observed previously. Water vapor observed at 3 heights over 3 consecutive days in an old-growth coniferous forest in the Pacific Northwest, USA, shows 1) a stratified nocturnal structure of hydrogen and oxygen isotope ratios in water vapor, with the most positive values consistently observed above the canopy (60 m): differences between 0.5m and 60m range between 2-6 per mil for oxygen-18 and 20-40 per mil for hydrogen-2 at night, and 2) an opposite transition between hydrogen and oxygen isotope ratios from nocturnal to daytime periods. Values of d-excess derived from rainwater and vapor samples suggest that considerable below-cloud secondary evaporation occurred during the descent of raindrops during our study period, driving a reverse pattern in hydrogen and oxygen isotopes of water vapor observed within the canopy. We support this interpretation by a canopy H2O isotope balance model to quantitatively distinguish relative contributions of different moisture sources to the observed pattern. The model successfully simulates principal features of the time evolution in the observed isotope ratios in canopy vapor. The results presented here demonstrate the interplay between the effects of vegetation and boundary layer mixing under the influence of rain evaporation, which has implications to larger-scale predictions of precipitation across the terrestrial landscape.

Ecogeomorphic Trends and Thresholds Along Climatic Transects

[H. Lavee], P. Sarah, Laboratory of Geomorphology and Soil, Department of Geography and Environment, Bar-Ilan University, Israel

The spatial variability of a number of "quick response" ecogeomorphological variables was studied along two climatic transects in Israel, the first one runs from west to east (W-E), covering an annual rainfall range of 700 – 100 mm, and the second runs from north to south (N-S), covering a rainfall range of 800 – 90 mm. Soil properties, runoff and sediment yield were investigated at the regional, plot and patch scales.

At the W-E gradient the study concentrated on the regional and plot scales. Soil samples were taken only from open areas between shrubs and overland flow was monitored in plots of 7, 14 and 21 m in length. At the regional scale it was found that: 1) high correlation exists between climatic conditions and ecogeomorphic variables (such as organic matter content, aggregate stability and soil moisture) and processes (such as infiltration and overland flow), and 2) the rate of change of these variables along the climatic transect is non-linear. A step-like threshold exists at the semi-arid area, which sharply separates the arid ecogeomorphic system, controlled by a-biotic factors such as soluble salts content and mechanical crust formation, from the Mediterranean sub-humid system controlled by biotic processes such as plant growth, microbial activity and organic matter production and decomposition. This means that even a relatively small climatic change is enough to shift the border between these two systems. As many regions of Mediterranean climate lie adjacent to semi-arid areas, they are threatened by desertification in the event of climate change.

At the plot scale it was found that: 1) a significant spatial variability of soil properties exists, in spite of measuring them only in the open areas. While the Mediterranean and the arid areas are characterized by a relatively uniform distribution (narrow range of values) of soil properties, a large range of values is typical of the transitional semi-arid area. 2) runoff coefficient decreases with increasing hillslope length, which means that there were water losses along the hillslope.

At the N-S gradient the spatial distribution of soil properties and overland flow at the patch scale was studied. Soil samples were taken from four micro-environments (under shrub (US), open area between shrubs (BS), under rock fragment and under tree) and overland flow was monitored in micro-plots representing US and BS patches. Organic matter content and aggregate size at the US were higher than in the BS, leading to higher infiltration rates. Runoff coefficients at the BS were always higher than at the US. The main conclusion is that the US areas function as sinks, so that at least part of the overland flow from the BS areas (that function as sources) infiltrate under the shrubs.

While in the sub-humid area, due to the high vegetation cover, most of the hillslope functions as a sink so that only saturated overland flow might develop from time to time, and in the arid area most of the hillslope functions as a source so that Hortons' overland flow appears quite frequently, a mosaic-like pattern of sources and sinks is typical to the semi-arid area, in accordance with the spatial distribution of shrubs. The existence of "arid"/source and "humid"/sink nuclei in the semi-arid area enables 1) most of the rainfall to be retained in the hillslope, and 2) relatively quick adaptation of the system to new conditions in the case of climate change.

Water Use Efficiency of Gambel's Oak in a Semi-arid Ponderosa pine Forest: Partitioning Between Transpiration and PhotoSynthesis Changes Along Spatial and Temporal Gradients

Darin J. Law[1] and Deborah M. Finch[2],
[1]University of Arizona, School of Natural Resources and the Environment, [2]USDA Forest Service, Rocky Mountain Research
Station, Albuquerque, NM

The efficient use of water is an attribute exhibited by many C3 plants of the semi-arid American Southwest. Plants can efficiently use water by maintaining a low transpiration rate relative to the rate of photosynthetic carbon reduction. On the other hand, plants can have high water use efficiency (WUE) by maintaining a high photosynthetic rate relative to the rate of water loss. Much research has been conducted showing that certain plants are more WUE than others which leads to plant survival and coexistence. Photosynthetic rates and transpiration rates have been studied individually and in concert and WUE has been determined to be relatively high or low but surprisingly little research has been performed on the interaction, partitioning and coupling between these controls over water use. The purpose of this research is to investigate whether or not the partitioning of the components of

WUE changes over spatial and temporal gradients to maintain high WUE. Stomatal conductance, transpiration, carbon isotope discrimination and photosynthesis were measured in central New Mexico. Results suggest that Gambels' oak spatially distant from a water source is more WUE than oaks near a water source. Oaks also become more WUE over time regardless of whether or not they grow near a water source. Abiotic measures of light, windspeed and soil water holding capacity suggest that WUE changes from a photosynthetic dominated process to a transpiration dominated process and may be due to increased woody plant cover and soil development over time. These results have important implications for how we manage woody plant cover and associated soil.

Evapotranspiration at an Arctic Coastal Desert Wetland, Barrow, Alaska

[*A K Liljedahl*] (International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK 99775; ph. 907-474-1951; fax 907-474-2643; e-mail: ftakl@uaf.edu); L D Hinzman (International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK 99775; ph. 907-474-7331; fax 907-474-5662; e-mail: lhinzman@iarc.uaf.edu); Y Harazono (International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK 99775; ph. 907-474-5515; fax 907-474-5662; e-mail: Y.Harazono@uaf.edu); D Zona (Center for Spatial Technologies and Remote Sensing, University of California Davis, CA 95616; ph. 530-752-5092; fax 530-754-5491; e-mail: dzona@ucdavis.edu); W C Oechel (Global Change Research Group, San Diego State University, San Diego, CA 92182; ph. 619-594-4818; fax 619-594-7831; e-mail: oechel@sunstroke.sdsu.edu); P Olivas (Department of Biological Sciences, Florida International University, FL 33199; ph. 305-348-6047; e-mail: poliv001@fiu.edu)

Limited hydrological storage capacity due to an impermeable permafrost layer near the surface, low hydraulic gradients and a relatively abundant supply of snowmelt water promote the existence of the extensive wetlands on the North Slope of Alaska despite a desert-like annual precipitation and a negative summer net precipitation (i.e. P-ET). Among the least understood components in arctic hydrology are water losses to the atmosphere by evapotranspiration and moisture transfer through the seasonally thawed ground.

We analyzed eddy covariance measurements from eight summer seasons at two drained thaw lakes basins (1999-2003 and 2006-2008), which represent a common feature of the Arctic Coastal Plain. Under current conditions at Barrow, potential evapotranspiration exceeds actual evapotranspiration. The fact that ground surface resistance to latent heat flux often increases (conductance decreases) as the summer progresses and the fact that vascular plants did not become water stressed during the unusually warm and low precipitation 2007 summer, strongly suggests that mosses controls late season decreases in surface conductance to water vapor flux. Evaporation likely dominates the total seasonal watershed evapotranspiration due to high surface conductance during a time period high solar radiation load at the surface.

Results indicate that vertical water loss from the coastal wetlands is dampened by the maritime climate. Unlike continental wetlands, sensible heat flux dominates the partitioning of available energy. This is mainly a result of the large temperature gradient between the warm ground surface and the cool, maritime air. Due to the steady sea breeze and the low probability of changes in the dominant wind direction, future evapotranspiration will likely remain at rates similar to those now observed. The projected increase in air temperature may therefore leave coastal wetlands less prone to soil drying compared to sites experiencing a continental climate.

A Sensitivity Study of Radiant Energy During Snowmelt in Non-Uniform Forests

[*T E Link*](University of Idaho; Water Resources Program; 975 West 6th Street; Moscow, ID 83844-1133, United States; (208) 885-9465; tlink@uidaho.edu); Essery, R (University of Edinburgh, School of Geosciences The King's Building, Edinburgh, EH9 3JW, United Kingdom); Pomeroy, J (University of Saskatchewan, 117 Science Place, Saskatoon, SK S7N 5C8, Canada); Marks, D (USDA - ARS, Northwest Watershed Research Center, 800 Park Blvd., Ste. 105, Boise, ID 83712, United States); Lawler, R (University of Idaho, Dept. of Forest Resources; 975 West 6th Street, Moscow, ID 83844-1133, United States)

In mountainous, forested environments, snowcover dynamics exert a strong control on hydrologic and atmospheric processes. Snowcover ablation patterns in forests are controlled by a complex combination of depositional patterns coupled with radiative and turbulent heat flux patterns related to topographic and canopy cover variations. Quantification of small-scale variations of radiant energy in forested environments is necessary to understand how canopy structure affects snowcover energetics to improve the representation of snowmelt processes in spatially-explicit physically-based snowmelt models. Incoming shortwave and longwave radiation were measured during the melt season within continuous and discontinuous forest stands, and at the interface between forest patches and small clearings along a transect spanning the North American Cordillera. Results indicate that reductions in solar radiation at the snow surface are partially balanced by increased thermal radiation from the forest canopy, relative to open locations. The differences between the transfer processes for solar and thermal radiation can produce two net incoming and net snowcover radiation paradoxes in heterogeneous environments. In discontinuous canopies, net radiation in forested areas may exceed radiation in open sites, whereas in other situations, net radiation may be less than net radiation in closed canopy forests. The empirical results coupled with theoretical modeling indicates that the effects of forest canopies on the radiative regimes at the snow surface are controlled by complex interactions of slope, aspect, gap sizes, canopy height, canopy density, canopy temperature, snow surface temperature, snowcover albedo, and timing of melt. In higher latitude, closed canopy forests, radiative regimes may be characterized by relatively simple geometric optical radiation transfer methods, whereas at lower latitude and more non- uniform forests, other processes such as canopy and stem heating must be considered. These net radiation differences coupled with decreased turbulent fluxes due to lower wind velocities and reduced snow water equivalent values due to canopy interception losses help to explain small-scale patterns of snowmelt in non-uniform forested areas. Future investigations will use physically based models coupled with LiDAR derived topographic and vegetation data to assess how these small-scale processes integrate in both space and time to control the timing and rates of snowcover ablation in complex vegetated terrain.

Determining the sensitivity of New Mexico biomes to predicted climate change scenarios of the Southwest

[*Marcy E. Litvak[1]*], Krista Anderson Teixera[2], and Andrew Fox[1], [1]Biology, University of New Mexico, Albuquerque, NM, [2]Plant Biology, University of Illinois at Urbana-Champaign, Urbana, IL

The varied topography and large elevation gradients that characterize the arid and semi-arid Southwest create a wide range of climatic conditions - and associated biomes - within relatively short distances. This creates an ideal experimental system in which to study the effects of climate on ecosystems. Such studies are critical given that the Southwestern U.S. has already experienced changes in climate that have altered precipitation patterns, and is expected to continue to experience dramatic climate change in the coming decades. Climate models currently predict a transition to a warmer, more arid climate in the Southwest. It is uncertain what impact this change might have on regional changes in energy balance, hydrologic partitioning, water resources and carbon storage.

We have a sequence of six widespread biomes along an elevation gradient in New Mexico -- ranging from hot, arid ecosystems at low elevations to cool, mesic ecosystems at high elevation to test specific hypotheses related to how climatic controls over ecosystem processes change across this gradient. This gradient offers us a unique opportunity to test the interactive effects of temperature and soil moisture on ecosystem processes as temperature decreases and soil moisture increases markedly along the gradient and varies through time within sites.

We are using eddy covariance towers and associated ecological and meteorological measurements in each biome to directly measure the exchange of carbon, water and energy between the ecosystem and the atmosphere. Here we focus on measurements made from 2007-2009 to compare the sensitivity of net ecosystem exchange, gross primary productivity and ecosystem respiration carbon to the distribution and size of precipitation pulses. These results have important implications for understanding the impact of various climate change scenarios on regional carbon storage.

Declining Annual Streamflow Distributions in the Pacific Northwest United States, 1948-2006

[*C H Luce*](USDA Forest Service Rocky Mountain Research Station, 322 E Front St., Boise, ID 83702; ph. 208-373-4382; email: cluce@fs.fed.us); Z A Holden (US Forest Service Region 1, 200 East Broadway, Missoula, MT 59807; ph. 406-329-3119; email: zaholden@fs.fed.us)

Much of the discussion on climate change and water in the western United States centers on decreased snowpack and earlier spring runoff. Although increasing variability in annual flows has been noted, the nature of those changes is largely unexplored. We tested for trends in the distribution of annual runoff using quantile regression at 43 gages in the Pacific Northwest. Seventy-two percent of the stations showed significant (alpha=0.10) declines in the 25th percentile annual flow, with half of the stations exceeding a 29% decline and a maximum decline of 47% between 1948 and 2006. Fewer stations showed statistically significant declines in either median or mean annual flow, and only five had a significant change in the 75th percentile, demonstrating that increases in variance result primarily from a trend of increasing dryness in dry years. The asymmetric trends in streamflow distributions have implications for water management and ecology well beyond those of shifted timing alone, affect both rain and snow-dominated watersheds, and contribute to earlier timing trends in high-elevation watersheds.

Influence of Post-fire Soil Water Repellence and Simulated Rainfall Regimes on Revegetation Success

[*M D Madsen*] (Department of Plant and Wildlife Sciences, Brigham Young University, Provo, UT 84602; ph. 801-669-2812; fax 801-422-0008; e-mail: madsenemail@gmail.com); S L Petersen (Department of Plant and Wildlife Sciences, Brigham Young University, UT 84602; ph. 801-422-4885; fax 801-422-0008; e-mail: steven_petersen@gmail.com)

Despite post-fire reseeding efforts, piñon-juniper woodlands often become invaded by annual weeds that out-compete native species, degrade ecological processes, and modify natural fire patterns. In order to develop successful restoration approaches, it is critical that we understand the mechanisms that impair vegetation recovery in these ecosystems. The development or enhancement of post-fire soil water repellence (WR) commonly occurs in these communities. However, the influence of this soil condition on revegetation success is poorly understood. The primary objective of this study was to quantify the influence of soil WR on soil hydrologic properties and revegetation success. Research was performed in the greenhouse using soil cores collected from the subcanopy of burned juniper trees. Treatments applied to soil cores included seeding Pseudoroegneria spicata or Agropyron cristatum, on WR soil and WR soil ameliorated through the use of wetting agents, with plants grown under high and low water regimes (high = 1.2 cm daily, low = 1.2 cm every 5 days). Results show that regardless of species, seeds that germinate in soils without wetting agent typically desiccate as a result of the WR layer disconnecting seedlings from the underlying soil moisture reserves. Differences between treatments were most pronounced under the low watering regime. For example P. spicata seedling densities under the high watering regime with wetting agent treated soil were 71% higher than untreated soils. In contrast, the density of plants growing in treated soils under a low watering regime was 700% higher than untreated soils. We hypothesize from these data that in semi-arid environments, soil WR acts as a temporal ecological threshold impairing establishment of desired species within the first few years after a fire, which then leaves resources available for weed invasion after WR has diminished.

Integrated Observations and Hydrologic Modeling over Snow-Dominated Mountain Basins

Danny Marks, Mukesh Kumar1 Michele Reba, Adam Winstral and Jeff Dozier1
USDA/ARS Northwest Watershed Research Center,Boise, Idaho

Over the last 50 years in the mountainous western US, climate change has modified the temporal and spatial distribution and magnitude of forcings, thereby altering the snowmelt-dominated hydrologic cycle in these watersheds by changing how seasonal snowcover and associated thermodynamics and melt processes are distributed over mountain landscapes. In an effort to understand how these hydro-climatic changes will impact streamflow and water supply, we have coupled the Pennsylvania State University Integrated Hydrology Model (PIHM) to the Isnobal energy balance snow model and applied it over a headwater basin in the Reynolds Creek Experimental Watershed (RCEW). The 0.4 km2 Reynolds Mountain East (RME) test basin is a highly instrumented watershed with a rich history of intensive winter field experiments, instrumentation and model development, testing and validation. Long-term data include meteorological variables (wind speed, humidity etc.), snow depth and mass, soil moisture and temperature and groundwater at multiple measurement sites, in addition to stream discharge at the outlet. The primary objective of this effort is to understand how the complex distribution of hydro-meteorological forcing parameters and associated hydrologic and thermodynamic processes determine the hydrologic state of a mountain basin. To this end, first we develop a suite of software tools and models to generate spatially distributed forcing fields of radiation, temperature, humidity, wind, precipitation and snow, based on convolving observations with GIS-derived topography and vegetation canopy structure. We then use the distributed fields to force the PIHM model to simulate coherent, coupled surface and sub-surface hydrologic processes across the basin. Because the forcing data are effectively over-specified in the RME basin, we are able to characterize the sensitivity of predicted spatial patterns of snow deposition and melt, soil moisture and temperature, evaporative losses to the atmosphere, and predicted streamflow from the basin to different levels of complexity in the forcing data. We are also able to specify how climate change will likely alter this complexity. This experiment allows us to develop a strategy for synergistic observation and modeling, which will help characterize the response of western mountain basins to climate warming. It will also allow us to determine the optimal configuration of observation sites in mountain basins, to assess the value of measuring additional parameters, and will ultimately lead to improved simulation modeling for water supply forecasts.

Understanding the Importance of Small Scale Hydrologic Variability to Successful River Management

[*A.K. McDonald*] (Water Management & Hydrologic Science, Texas A&M University, College Station, TX 77843; ph. 432-336-8585; fax 432-336-3813; e-mail: akmcdonald@ag.tamu.edu); Z. Sheng (Department of Biological and Agricultural Engineering, Texas AgriLife Research, El Paso, TX 79927; ph. 915-859-9111; fax 915-859-1078; e-mail: z-sheng@tamu.edu); B.P. Wilcox (Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843; ph. 979-458-1899; fax 979-845-6430; e-mail: bwilcox@tamu.edu); C.R. Hart (Department of Ecosystem Science & Management, Texas AgriLife Extension, Stephenville, TX 76401; ph. 254-968-4144; fax 254-965-3759; e-mail: cr-hart@tamu.edu)

Rivers are broadly characterized as gaining or losing streamflow from or to the adjacent groundwater, respectively. However, small scale variability in ground water flowpaths may determine the success of management efforts such as phreatophyte control, reservoir release and delivery, and groundwater storage or enhanced recharge. Specifically, if a river is dominated by losing reaches, then sustained streamflow will not be enhanced by reducing riparian evapotranspiration; the salvaged water will contribute to groundwater recharge. The objectives of this study were to examine spatial and temporal dynamics of stream-aquifer interaction and the influence of stress created by riparian evapotranspiration (ET) on local groundwater flowpaths and hydraulic gradients. Analysis of stream stage and groundwater elevation data indicates that the study reach is constantly losing water to the shallow aquifer, even under very low flow conditions. Riparian ET stress did not influence hydraulic gradients or flow direction. Estimates of saltcedar annual water use at this study site range from 0.43 m to 1.18 m. A median value of 0.76 m is equivalent to between 2% and 4% of the seepage loss, which may explain the lack of influence on groundwater flowpaths and hydraulic gradient.

Hydrological Stores and Fluxes Along Elevation Gradients in the Dry Creek Watershed

[*J P McNamara*] (Department of Geosciences, Boise State University, Boise, ID 83725; ph. 208-426-1354;fax 208426-4061; e-mail: jmcnamar@boisestate.edu); S G Benner (Department of Geosciences, Boise State University, Boise, ID 83725; e-mail: sgbenner@gmail.com); D G Chandler (Department of Civil Engineering, Kansas State University, Manhattan, KS 66506; email dgc@ksu.edu) ; M M Gribb (Department of Civil Engineering, Boise State University, Boise, ID; email mgribb@boisestate.edu)

Catchment hydrologists commonly seek to understand hydrologic fluxes governing the “loss” of water by processes including runoff generation, streamflow, evapotranspiration, soil water flow, and groundwater recharge. For many ecohydrological problems, however, we are not necessarily interested in understanding how water leaves a catchment, but how it is retained. This necessitates a different conceptualization of the role of landscape properties in catchment hydrology. While it is relatively easy to monitor or model fluxes, distributed estimates of storage are challenging. It is the storage mechanisms and resistance to flow, rather than conductance that control important measures such as residence time, moisture distribution, and water availability. In this study, we consider the water balance of a semi-arid, snowmelt driven catchment from the perspective of storage. We illustrate examples of how storage mechanisms influence soil moisture distribution, streamflow generation and cessation, and stream nutrient dynamics for sites along an elevation gradient in the Dry Creek Experimental Watershed in southwest Idaho.

Improving Modeled Snowmelt Energetics in Semiarid Shrub Landscapes Through a Better Representation of Vegetation Characteristics

[*C B Menard*] (School of GeoSciences, University of Edinburgh, Edinburgh EH9 3JW, UK; ph. +44 131 651 9093; fax +44 131 668 3184; email: c.b.menard@sms.ed.ac.uk); R Essery (School of GeoSciences, University of Edinburgh, Edinburgh EH9 3JW, UK); D Clark (Centre for Ecology and Hydrology, Wallingford OX10 8BB); J Pomeroy (Department of Geography, University of Saskatchewan, Saskatoon, Canada)

Shrubs have important influences on snow distributions in cold, semiarid regions: they limit wind redistribution and winter sublimation by trapping snow, thus leading to a deeper snowpack, greater soil insulation and warmer temperatures, and increased spring snowmelt water. The energy balance and albedo of the region are affected by an increase in exposed vegetation and by the bending or burial of shrubs in winter and their straightening in spring. In order to understand the land surface?atmosphere feedbacks, physically-based models need to be able to represent the spatial heterogeneity of the landscape. In this study, a simple multiple source model is developed to represent shrub and snow energetics at high resolution. A parameterization for the burial and exposure of shrubs is implemented in a spatially distributed surface energy balance model driven with meteorological data and evaluated against eddy-covariance flux measurements from the Wolf Creek Research Basin, Yukon Territory, Canada. The distribution of shrubs in the basin is characterized using photographs, LiDAR and field surveys. A simpler parameterization accounting for subgrid heterogeneity is proposed for an aggregated land surface model. We conclude that simple model developments can produce better representations of the landscape energy balance and hydrological processes and are expected to facilitate simulations on the impact of climate change in the region.

Upscaling Sap Flow: Observations From a Pilot Study and Implications for Transpiration Measurement Across a Gradient

[*G R Miller*] (Department of Civil and Environmental Engineering, University of California, Berkeley; Affiliation Starting Fall 2009: Department of Civil Engineering, Texas A&M University, College Station, TX 77843-3136; email: gmiller@civil.tamu.edu); X Chen (Department of Civil and Environmental Engineering, University of California, Berkeley, Berkeley, CA 94720-1710; email: chenxy@berkeley.edu); D D Baldocchi (Department of Environmental Science, Policy, and Management, University of California, Berkeley, Berkeley, CA 94720-1710; email: baldocchi@nature.berkeley.edu); Y Rubin (Department of Civil and Environmental Engineering, University of California, Berkeley, Berkeley, CA 94720-1710; email: rubin@ce.berkeley.edu)

The eddy-covariance method has been a tremendous tool for measuring plant evapotranspiration, but it is notoriously difficult to apply over topography, limiting its use in ecohydrological studies across mountainous transects. Sap flow measurements overcome this limitation, but upscaling them is also problematic, particularly when selecting which trees to monitor. In this paper, we present a pilot study for upscaling transpiration measurements in a semi-arid oak savanna, comparing evapotranspiration rates from sap flow to those found using the eddy-covariance technique. The method developed uses a combination of geostatistical, artificial intelligence, and flux footprint tools along with high-resolution Lidar data and soil texture

sampling to locate and upscale the sap flow measurements.

During the two-year study, we monitored sap flow and soil moisture environment of eight carefully selected trees. We found that a combination of tree diameter, height, elevation, leaf area, and canopy radius best explained the variability in sap velocity among this limited set of trees. However, we also observed that large trees, in the top 10th percentile for diameter, contributed a disproportionate amount to the total stand-level flux. These findings indicate that monitoring efforts that concentrate on the variation in sap velocity of large trees could produce more representative flux values; emphasis should be placed on how these rates vary radially within the stem of a large tree and how they vary between individual trees in different light and water environments. We extrapolate the lessons learned from this study to suggest future methods for locating sap flow sensors across elevation gradients.

Quality Assessment, Reserve Estimation & Economic Analysis of Roofing Slate in the West Central Lesser Himalaya-Nepal

[*N R Neupane*](Department of Environmental Science, Amrit Campus, Tribhuvan University, Thamel, Kathmandu, Nepal, ph. 977-1-691-1780, email: nneupane@gmail.com); L P Paudel (Central Department of Geology, Tribhuvan University, Kathmandu, Nepal, ph. 977-1-433-2449, email: tugeology@wlink.com.np)

Quality Assessment, Reserve Estimation and Economic Analysis of Roofing Slate can be carried out at Tharpu of Tanahun District, which lies in the Nawakot complex of the Lesser Himalaya-Nepal. It represents a part of northern limb of the Mahabharat Synclonorium. Petrological study (Presser and Temperature of Metamorphism, and Thing Section) and Physio-chemical Test (Flexure Testing, Water absorption, Wethering Resistance, Abration Resistance, Sulphuric Acid Immersion Test, Wetting and Drying Test) have been done in the laboratory for quality assessment. Geological mapping and preparation of columnar sections have been done in the field for Reserve Calculation. The total reserve of an area is determined by dividing the tonnage with its tonnage factor. The volume is calculated by multiplying the total cross-section area by the perpendicular distance between each cross-section. Cost Benefit Analysis was applied for cost and benefit of slate mining to evaluate the viability of the slate business as well as environmental problem created due to the extraction of slate.

The major slate deposits of the study are belonging to the Benighat Slate and Nourpul Formation of the Lesser Himalaya. The pressure and temperature of the metamorphism on the basis of b0-spacing and IC methods are 4.23 kbar and 380☐ C for Benighat Slate and 5.10 kbar and 375☐ C for Nourpul Formation roofing slate. Flexure strength of the slate along grain ranges from 26. 26 to 50.57 MPa with average 36.24 MPa and standard deviation (SD) of 9.28 MPa. While, the same property across grain ranges from 36.37 to 59.78 MPa with average value 43.1 MPa and SD of 9.59 MPa. Similalry, the elasticity of the tested sample of slate ranges from 1055.4 to 2974 MPa having mean value of 1774 MPa and SD of 740 MPa. Water absorption by weight is 0.789 to 1.473 having mean value 1.02 and SD 0.3. While, the weather resistance of the slate lies within 0.31 mm to 0.55 mm with average value of 0.41 mm and SD is 0.1. Abrasion by weight has a range from 14.3 to 20.4 with average value 16.22 and SD 2.73. The permeability, sulphuric acid immersion, and wetting and drying tests give excellent results to the slate.

It was observed that from the field study, there is fine-grained with a fairly perfect natural cleavage, readily splitable into thin and smooth sheets of slate at Seratar (3000 m northwest from Tharpu Bazaar) and Otandi (1000 m west from Tharpu Bazaar). Due to this thin splitting properties, most slate are used for roofing purposes. On the basis of physio-chemical testing and

Petrological study, the slate of Nourpul Formation at Seratar and Benighat slate at Otandi are best for roofing as well as construction purpose even though inferior to the ASTM standard.

The total probable reserve of the slate calculated by the cross-sectional method is to be 52.9 million m3 at Otandi. Mining method appropriate for the slate deposit is open pit mining. As cost benefit analysis (B/C ratio = 1.23), the mining of slate is good profitable. For profitable business, the benefits and cost ratio should always be greater than one. However, the slurry of quarry materials is affecting downward forest, water bodies and agriculture land with environmental degradation.

Hydrological Response of Catchment Management in the North Ethiopian Highlands

[*J Nyssen*] (Department of Geography, Ghent University, B ? 9000 Gent, Belgium; ph. 0032 9 264 46 23; email: jan.nyssen@ugent.be); W Clymans (Department of Earth and Environmental Sciences, K.U.Leuven, B ? 3001 Heverlee, Belgium; email: Wim.clymans@ees.kuleuven.be); K Descheemaeker (International Water Management Institute / International Livestock Institute, Addis Ababa, Ethiopia; email: K.Descheemaeker@cgiar.org); J Poesen (Department of Earth and Environmental Sciences, K.U.Leuven, B ? 3001 Heverlee, Belgium; email: Jean.poesen@ees.kuleuven.be); I Vandecasteele (Department of Geology, Ghent University, B ? 9000 Gent, Belgium; email: Ine.vandecasteele@ugent.be); M Vanmaercke (Department of Earth and Environmental Sciences, K.U.Leuven, B ? 3001 Heverlee, Belgium; email: Matthias.vanmaercke@ees.kuleuven.be) ; Amanuel Zenebe (Department of Land Resources Management and Environmental Protection, Mekelle University, Mekelle, Ethiopia; email: amanuelza@yahoo.com); Mitiku Haile (Department of Land Resources Management and Environmental Protection, Mekelle University, Mekelle, Ethiopia; email: gualmitiku@yahoo.com); J Moeyersons (Royal Museum of Central Africa, B ? 3080 Tervuren, Belgium; email: mrsons@africamuseum.be); K Martens (Department of Geology, Ghent University, B ? 9000 Gent, Belgium; email: Kristine.martens@ugent.be); M Van Camp (Department of Geology, Ghent University, B ? 9000 Gent, Belgium; email: marc.vancamp@ugent.be); J Deckers (Department of Earth and Environmental Sciences, K.U.Leuven, B ? 3001 Heverlee, Belgium; email: seppe.deckers@ees.kuleuven.be); K Walraevens (Department of Geology, Ghent University, B ? 9000 Gent, Belgium; email: Kristine.walraevens@ugent.be)

Catchment management in the developing world has been demonstrated to pay off in economic terms yet such studies rarely include detailed hydrological components. Changes in the hydrological response of the 200-ha May Zeg Zeg integrated catchment management area (near Hagere Selam, North Ethiopia) were studied for the period 2000-2006, before and after catchment management. The catchment management included various soil and water conservation measures such as the construction of dry masonry stone bunds on farmland and check dams in gullies, abandonment of post-harvest grazing on cropland and the establishment of woody vegetation on degraded rangelands. Measurements of rain depth and runoff discharge at the catchment outlet indicated a runoff depth of 5 mm or a runoff coefficient (RC) of 1.6 % in the rainy season of 2006. Combined with runoff measurements at plot scale, this allowed calculating the runoff Curve Number (CN) for various land uses and land management techniques pre and post implementation of catchment management. The pre-implementation runoff was then predicted using the calibrated CN values (taking into account stone bund construction and reduced grazing), as well as a ponding adjustment factor, representing the abstraction of runoff induced by the 242 check dams in gullies. Using the 2006 rainfall depths, the runoff for the 2000 land-use and management situation in the catchment, was predicted to be 26.5 mm. This corresponds to a RC of 8 %, which is in line with current RCs of nearby catchments. Monitoring of the water table in a piezometer in the upper valley bottom indicate a rise of ground water levels after catchment management. When the rise in water table after the onset of the rains (?T) is given relative to the water surplus (WS) over the same period, a large difference is seen between 2006 (?T/WS > 11.1) and 2002-2003 (?T/WS = 3.4). Emerging wells and irrigated fields are other indicators for an improved hydrological balance and water supply in the study area brought about by catchment management. Cropped fields in the lower gully system also indicate that farmers are less frightened for flash floods with destructive effects on their cropland. Due to greater soil water content, the period of water uptake by crops is prolonged. It is clear that this catchment management has resulted in a higher infiltration rate and a reduced direct runoff volume which has had a positive influence on the catchment water balance. Increased water availability leads to higher crop yield and crop diversification by the farmers.

Soil CO2 Fluxes Following Wetting Events: Field Observations and Modeling

[*Frances O'Donnell*] (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ, 08544; ph. 609-258-4869; fax 609-258-2799; email: fodonnel@princeton.edu); Kelly Caylor (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ, 08544; ph. 609-258-4614; fax 609-258-2799; email: kcaylor@princeton.edu)

Carbon exchange data from eddy flux towers in drylands suggest that the Birch Effect, a pulse of soil CO2 efflux triggered by the first rain following a dry period, may contribute significantly to the annual carbon budget of these ecosystems. Laboratory experiments on dryland soils have shown that microbes adapted to live in arid ecosystems may be able to remain dormant in dry soil for much longer than expected and an osmotic shock response to sudden increases in soil water potential may play a role in the Birch Effect, but little has been done to understand how a dry soil profile responds to a rainfall event. We measured soil CO2 production during experimental wetting events by burying small, solid-state sensors that continuously measure CO2 concentration in the soil air space at four depths and the soil surface in treatment plots at a site on the Botswana portion of the Kalahari Transect (KT). We then applied wetting treatments intended to simulate typical rainfall for the region to the plots, including single 10 mm wettings (the mean storm depth for the KT), single 20 mm wettings, and repeated 10 mm wettings. We solved a finite difference approximation of the governing equation for CO2 in the soil airspace to determine the source rate of CO2 during and after the wetting treatments, using Richard's equation to approximate the change in air-filled porosity due to infiltrating water. The wetting treatments induced a rapid spike in the source rate of CO2 in the soil, the timing and magnitude of which were consistent with laboratory experiments that observed a microbial osmotic shock response. The source rate averaged over the first three hours after wetting showed that a 20 mm wetting produced a larger response than the 10 mm wettings. It also showed that a second wetting event produced a smaller response than the first and though it was not significant, an upward trend in response was apparent through the two month period. These results suggest that there may be a build-up of labile carbon in the soil during dry periods that becomes available for respiration when the soil is wetted, a hypothesis about the Birch effect that has received little attention in lab studies. Future work in this area will investigate whether or not this explanation is feasible by using glucose addition experiments to determine if the magnitude of the observed respiration pulse is affected by substrate ability.

Connectivity and Ecohydrological Feedbacks in Desertification

[*GS Okin*] (Department of Geography, 1255 Bunche Hall, UCLA, Los Angeles, California, 90095, USA, Phone: +1-310-825-1071, Fax: +1-310-206-5976, e-mail: okin@ucla.edu); J. Stewart (Department of Geography, The University of Sheffield, Sheffield S10 2TN, UK, Phone: +44 114 222 7900, Fax: +44 114 279 7912, email: Jill.Stewart@sheffield.ac.uk); J.E. Herrick (USDA ARS Jornada Experimental Range, 2995 Knox St., Las Cruces, NM, 88003, USA, Phone: +1-575-646-4842, Fax: +1-575- 646-5889, e-mail: Jeffrey.Herrick@ars.usda.gov); A.J. Parsons (Department of Geography, The University of Sheffield, Sheffield S10 2TN, UK, Phone: +44 114 222 7952, Fax: +44 114 279 7912, email: A.J.Parsons@Sheffield.ac.uk); J. Wainwright (Department of Geography, The University of Sheffield, Sheffield S10 2TN, UK, Phone: +44 114 222 7951, Fax: +44 114 279 7912, email: J.Wainwright@Sheffield.ac.uk); D.P.C. Peters (USDA ARS Jornada Experimental Range, 2995 Knox St. , Las Cruces, NM, 88003, USA, Phone: +1-575-646-2777, Fax: +1-575- 646-5889, e-mail: debpeter@nmsu.edu); B.T. Bestelmeyer (USDA ARS Jornada Experimental Range, 2995 Knox St. , Las Cruces, NM, 88003, USA, Phone: +1-575-646-4842, Fax: +1-575- 646-5889, e-mail: Brandon.Bestelmeyer@ars.usda.gov)

Deserts are patchy. Specifically, vegetation-covered areas in deserts are often interspersed with patches of bare ground. The patchiness is manifest at a wide range of spatial scales and is typically associated with a characteristic microtopography. The correspondence of vegetation patches with microtopographic features suggests strong interactions between surface transport and vegetation patches, and thus a close relationship between geomorphology, biology, and hydrology in dryland systems. We propose that understanding connectivity in deserts is key to understanding both the form (i.e., patchy) and function (i.e., dynamic) of these systems. Specifically, the connectivity hypothesis argues that transport by wind and water is 1) a function of the connectedness of non-vegetated patches and 2) fundamentally responsible for causing patchiness in the first place. Thus, we hypothesize that patchiness arises due to feedbacks between patches, surface hydrology, animals, and transport of sediment, nutrients and propagules. Results from a new quantitative model of connectivity in deserts will be discussed.

Thresholds and Feedbacks Between Rainfall, Soil Moisture, Evapotranspiration, and Groundwater Recharge: A Microcosm Experiment

[*L A Pangle*](Department of Forest Engineering, Resources and Management, Oregon State University, 204 Peavy Hall, Corvallis, OR 97331; phone: 706-224-8073; e-mail: Luke.Pangle@oregonstate.edu); J Gregg (Terrestrial Ecosystem Research Associates, 200 SW 35th Street, Corvallis, OR 97333; e-mail: Gregg.Jillian@epamail.epa.gov); J J McDonnell (Department of Forest Engineering, Resources and Management, Oregon State University, 204 Peavy Hall, Corvallis, OR 97331; phone: 541-737-8720; e-mail: Jeffrey.McDonnell@oregonstate.edu)

Many of the most pressing ecohydrological questions now focus on the highly non-linear and interacting components of the soil-plant-atmosphere continuum. Nevertheless, experimental work is often forced to measure many of the key elements of evapotranspiration, soil moisture dynamics, and groundwater recharge in isolation from one another due to boundary condition restrictions in natural systems. As a result, theoretical modeling approaches have now outpaced efforts to describe these processes using empirical data. Here we present new data from a controlled microcosm experiment that examines mechanistically the thresholds and feedbacks between rainfall, soil moisture, evapotranspiration, and groundwater recharge. Specifically,

what is the effect of induced warming scenarios on soil-water-vegetation feedbacks? How do symmetric and asymmetric warming scenarios affect the interactions between water balance components? And, how do climate induced feedbacks express themselves across different time scales? The microcosms replicate the ecohydrology of temperate grasslands within a temperate Mediterranean climate in Oregon's Willamette Valley, USA. The facility includes twelve outdoor chambers of 2m3 volume, each overlaying 2m3 of native soil that is contained by lysimeter. The experimental capabilities include real-time control of air temperature, relative humidity, dew point, and atmospheric [CO2], with two imposed heating treatments: a symmetric warming treatment with temperature constantly 3.5°C greater than ambient, and an asymmetric warming treatment, where daily minimum temperature is 5°C greater than ambient, while daily maximum temperature is 2°C greater than ambient. Hydrologic measurements obtained in real-time include precipitation, evapotranspiration, volumetric soil moisture, and water losses to groundwater recharge. Preliminary results to date indicate differences in the timing and magnitude of groundwater recharge and evapotranspiration during spring rain events for heated versus ambient microcosms, and differences in evapotranspiration among asymmetric and symmetric warming scenarios. These results have significant implications for how future-warming scenarios may modify the ecohydrology of grassland ecosystems in Mediterranean climate regimes.

Linking ecology, hydrology, and decision-making in semi-arid cities

[*D E Pataki*] (Department of Earth System Science and Department of Ecology & Evolutionary Biology, University of California, Irvine, CA 92697-3100; ph. 949-824-9411; fax 949-824-3874; e-mail: dpataki@uci.edu); H R McCarthy (Department of Earth System Science, University of California, Irvine, CA 92697-3100; ph. 949-824-1838; fax 949-824-3874; e-mail: heather.mccarthy@uci.edu); N S Bijoor (Department of Earth System Science, University of California, Irvine, CA 92697-3100; ph. 949-824-2935; fax 949-824-3874; e-mail: nbijoor@uci.edu); E Litvak (Department of Earth System Science, University of California, Irvine, CA 92697-3100; ph. 949-824-2935; fax 949-824-3874; e-mail: elitvak@uci.edu)

Semi-arid urban ecosystems present a unique challenge in understanding ecohydrology. Urban landscapes are highly modified, not only by built structures and impervious surfaces, but also by a unique mix of vegetation and soils. These landscapes are often irrigated using imported water from remote sources. The result is a human-dominated hydrologic cycle influenced by many aspects of individual, household, and institutional rules and decision-making as well as biophysical factors. In most urban and urbanizing regions, the hydrologic budgets, ecohydrologic feedbacks, and their key controls are highly uncertain due to the complex interactions between social, biotic, and abiotic factors. Here, we review ecohydrologic research in Los Angeles, the second largest city in the United States and one of the world's "mega-cities" with inhabitants in excess of 10 million. This region is experiencing a prolonged drought and reductions in allotments of imported water. Outdoor irrigation is a large component of municipal and household water use in this region. Therefore, understanding the magnitude, variability, and controls on surface evaporation, plant transpiration, runoff, and groundwater recharge is critical for planning and managing water resources, and for coping with predicted water shortages. We have found a high degree of variability in transpiration rates of irrigated plants in Los Angeles. Urban forest transpiration is highly sensitive to the choice of species, even given similar planting densities. In contrast, we have found that ET is less sensitive to the selection of irrigation technologies and to general categories of native vs. non-native landscapes. We compare and contrast the water budgets of urban landscapes with varying species composition and management practices and discuss the implications for regional ecohydrologic feedbacks and for managing scarce water resources. As urbanization continues at a rapid pace in semi-arid regions, it will become increasingly important to consider the role of urban land use and land cover in influencing hydrological and ecological processes at local to regional scales.

Microclimate Controls on Slope Angles in the Idaho Batholith

[*M J Poulos*] (Dept. of Geosciences, Boise State University, Boise, ID 83725-1535; ph. 208-841-1406; fax 208-426-4061; e-mail: mikepoulos@u.boisestate.edu); J L Pierce (Dept. of Geosciences, Boise State University); T Smith (Dept. of Geosciences, Boise State University); S Benner (Dept. of Geosciences, Boise State University); A Flores (Dept. of Geosciences, Boise State University); J McNamara (Dept. of Geosciences, Boise State University); M Gribb (Dept. of Civil Engineering, Boise State University)

Insolation-driven variation in soil moisture and evapotranspiration between north- and south-facing slopes drives feedbacks with (1) vegetation type and density, (2) weathering rates and processes, (3) erosion rates and processes. In turn, differences in the balance between weathering and erosion produce contrasting slope angles across aspects. In the desert Southwest, south-facing slopes form cliffs because they lack sufficient soil moisture for weathering (Burnett et al., 2008). However, in semi-arid regions of the Idaho Batholith, north-facing slopes are often significantly steeper than south-facing slopes, suggesting contrasting ecohydrologic conditions might be responsible. We develop and apply spatial analysis techniques to examine slope angle and aspect relationships in tectonically quiescent areas of the mostly-homogenous, granodioritic Idaho Batholith. In three of five watersheds selected, average north-facing slopes are 3-8° steeper than south-facing slopes. The smallest study area, the Dry Creek Experimental Watershed near Boise, Idaho, showed the greatest sensitivity of slope angles to aspect, with average northern slope angles of 29°, and southern slope angles of 21°. Initial comparisons of soil textures at 15 cm depth across different aspects found soils to contain 29-41% silt on north-facing slopes, and 11-12% silt on south-facing slopes. Possible explanations include increased weathering on north-facing slopes, increased capture of wind-borne loess due to vegetative wind-baffling, and differences in the type and magnitude of erosive processes. Ongoing study seeks to 1) use large-scale DEM analysis to correlate the sensitivity of aspect control on slope angle to changes in soil moisture and 2) understand the spatial distribution and relative influences of erosive processes that limit slope angles (e.g. wash, mass failures, etc.), and cohesive forces that stabilize slopes (e.g. root strength, soil texture, and soil moisture) within selected watersheds.

Resource Redistribution Patterns Induced by Rapid Vegetation Shifts and Their Impacts on Desertification

[*Sujith Ravi*], Travis E Huxman, Javier Espeleta (B2 Earthscience & UA Biosphere 2, University of Arizona, Tucson, AZ 85721; ph: 520-838-6200; fax: 520-626-0739; e-mail: ravi@email.arizona.edu); Paolo D'Odorico (Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22904; ph: 434-924-7241; fax:434-982-2137; e-mail: paolo@virginia.edu), Scott L Collins (Department of Biology, University of New Mexico, NM 87131; ph: 505-272-6303; fax: 505-272-5355; e-mail:scollins@sevilleta.umn.edu).

A common form of land degradation at the desert margins is the rapid interconversion of vegetation between grasses and woody plants (e.g. woody plant encroachment in to grasslands;

exotic grass invasion in to shrublands), with ecohydrological and biogeochemical consequences. Here we show, using a combination of field experiments and a spatially explicit model, that the process of degradation can be facilitated both by an increase in heterogeneity (shrub encroachment in to grasslands) and in homogeneity (exotic annual grass invasion into desert shrublands) of soil resources, depending on the plant functional type inducing the change in soil resource distribution. Both shrub encroachment and exotic grass invasions affect fire regime and soil erosion rates, altering the spatial distribution of soil resources (e.g., carbon, nitrogen, and water). Conversion of native perennial grasslands into shrublands increases soil resource heterogeneity as a result of hydrological and Aeolian transport processes. Our studies in the shrub-native grass ecotone in the Northern Chihuahuan desert have shown that recurrent fires can counteract the formation of heterogeneity, in that the interaction of fires with soil erosion favors a more homogeneous distribution of soil resources. Through a near-identical mechanism, invasion by exotic annual grasses can increase fire frequency, shrub mortality, and soil loss, thereby destroying the heterogeneity of resources typical of desert shrublands and favoring the conversion into exotic annual grasslands. However, long-term persistence of invasive grass cover is restricted due to low frequency recurrent drought that displaces the annual life form. Drought-induced loss of vegetation cover is expected to be followed by even higher erosion rates and irreversible losses of soil resources. The mechanism we propose suggests that two major drivers of global environmental change, namely biological invasions and climate change, may act in concert and amplify each other's effect on land cover and soil resources.

A 25-year Dataset for Hydrologic Modeling from a Semiarid Research Watershed- Reynolds Creek Experimental Watershed

[*M L Reba*] (USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Suite 105, Boise, ID 83712; ph. 208-422-0727; fax 208-334-1502; email: michele.reba@ars.usda.gov); D G Marks (USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Suite 105, Boise, ID 83712; ph. 208-422-0721; fax 208-334-1502; email: ars.danny@gmail.com); A Winstral (USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Suite 105, Boise, ID 83712; ph. 208-422-0739; fax 208-334-1502; email: adam.winstral@ars.usda.gov <mailto:ars.danny@gmail.com>);

Carefully collected, processed, and validated meteorological datasets for hydrological modeling from semiarid mountain environs are rare. This study presents 25-years of such a dataset from the Reynolds Creek Experimental Watershed, located in southwest Idaho, USA. The dataset includes meteorological data of air temperature, vapor pressure, wind speed, solar and thermal radiation, and soil temperature from two locations for water year 1983 through 2008. Validation of meteorological data includes simulations from a distributed mass and energy balance model (ISNOBAL) validated with measured snow water equivalent. Additionally, supporting spatially-distributed information is also available and includes soils and bedrock information, 10 m DEM, and vegetation information. Use of this dataset will allow for detailed comparisons of simulations from various hydrological modeling approaches in semiarid mountain environs and lend insight into trends in measured meteorological data in a changing climate.

Linking Hydrology and Biogeochemistry to Assess the Impact of Lateral Nutrient Fluxes

[*K T Rebel*] (Copernicus Institute for Sustainable Development and Innovation, Department of Geosciences, P.O. Box 80115, Utrecht University, Utrecht, the Netherlands; ph. +31 20 253 5898; e-mail: k.rebel@geo.uu.nl);

F. van Osch (Copernicus Institute for Sustainable Development and Innovation, Utrecht University, Utrecht, the Netherlands, F.P.VanOsch@students.uu.nl); K J McGuire (Virginia Water Resources Research Center & Dept. of Forest Resources & Environmental Conservation, Virginia Tech, Blacksburg, VA 24061, USA, kevin.mcguire@vt.edu); E B Rastetter (The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543, USA, erastetter@mbl.edu)

Until recently, it has been challenging to couple hydrologic and biogeochemical processes at the watershed scale. We have coupled two models, WTB and MEL, to simulate lateral water and nutrient fluxes and their influence on ecosystem functioning. WTB is a spatially explicit water balance model. Vertical flow was simulated using a capacitance model with lateral flow dependent on head development and the local slope of the confining layer. The Multiple Element Limitation (MEL) model is an ecosystem model, developed to examine limitation in vegetation acclimating to changes in the availability of two resources (carbon and nitrogen). MEL also incorporates the recycling of resources through the soil. In our coupled model, nutrients are treated as inert solutes and are transported vertically as well as laterally using a mixing model. Nutrients moving down the slope are repeatedly taken up, cycled through vegetation and soils, and released back into the soil solution.

We evaluated the impact of adding lateral nutrient fluxes to the original MEL model using a virtual experiment. The model (coupled and MEL only) was applied to a small, well defined catchment. After a simulation period of three years, we detect a redistribution of the stock of inorganic N. A larger amount of N is present near the river than at the top of the slopes of the catchment, largely due to lateral fluxes. Comparing the coupled model to the MEL model, we also find large losses of inorganic N in the coupled model due to large vertical fluxes out of the rootzone. These vertical out-fluxes cause a smaller N uptake by plants. To detect if Carbon (C) uptake by plants is affected due to the changes in N distribution, the simulation period has to be increased due to a lagtime in the optimization of the C:N ratio in plant biomass.

Prediction of Yangjiashan Creeping Slope's Next Landslide Cycle

[Diandong Ren], Rong Fu, Lance M. Leslie and Xin Xiang, Department of Geological Sciences, The University of Texas at Austin, Austin, TX 78712, U. S.; b School of Meteorology, The University of Oklahoma, Norman, OK 73072; c China University of Geosciences (wuhan) 388 Lumo Road, Hongshan District, Wuhan, Hubei Provience, China, P.R.

Being able to predict the locations and timing of mudslides, especially using numerical models with sufficient lead time is a scientifically challenging problem, but extremely important to mitigate the landslide impact. We develop an unprecedented dynamic modeling system for monitoring storm-triggered landslides and its ecosystem implications. The model ingests conventional as well as remotely sensed topographic and geologic datasets while outputs the diagnostics valuable for near-real-time assessment of the societal impacts of landslides. We tested the system for a data rich region along the Yangtze river, our estimation of creeping rates are satisfactory (within only 0.5 mm/yr root mean squared errors) compared with borehole measurements. We also made a prediction of the creeping curve for the upcoming year 2010, taking the basal movements associated with the Wenchuan earthquake into consideration. Significant slope movement will occur within the upcoming five years, even if there is no change to the current precipitation morphology. If there is an unfortunate combination with a storm of over 150 mm precipitation amount, the sliding is imminent. Sensitivity experiment helps identify a sticky point overlooked by the survey team. This location may serve as the first sliding block and trigger a domino-style sliding progressing uphill in case of storm-caused instability.

Ecohydrological Consequences of Woody Plant Encroachment in Bottomland and Upland Locations of the Sonoran Desert

[*R L Scott*; T E Huxman; G D Jenerette; E P Hamerlynck; G A Barron-Gafford; D L Potts] (Southwest Watershed Research Center, USDA-ARS, 2000 E. Allen Rd., Tucson, AZ 85719; ph. 520-670-6380; e-mail: russ.scott@ars.usda.gov)

Woody plant encroachment is a widespread phenomenon in semiarid regions with unknown consequences in affecting the timing and magnitude of ecosystem water and carbon exchanges. Here we summarize results from our on-going work to better understand the consequences of the conversion of grasslands to mesquite (Prosopis velutina) savannas or woodlands in riparian and upland regions of the Sonoran Desert to highlight the influence of landscape position. In a riparian setting, shallower-rooted grasses are less able to fully exploit stable groundwater sources, whereas the ecohydrological exchanges of encroached ecosystems become more decoupled from precipitation as the ecosystems become more woody. This results in a tradeoff between more carbon sequestration at the expense of greater water use in an region of over-exploited groundwater resources. In the upland setting, differences in water use are harder to detect, but probably quite small. However, upland grassland net carbon exchange appears to be much more responsive to current precipitation input, whereas the encroached ecosystems show more lag effects from drought and rainy periods.

Soil Water Content and Global Change Across an Elevation Gradient at Reynolds Creek, Idaho

[*M S Seyfried*] (USDA-ARS, Boise, ID, 83712; ph 208-422-0715; fax 208-334-1503; e-mail: mark.seyfried@ars.usda.gov); D Chandler, Kansas State University, Manhattan, KS 66505; ph 785-532-3123; e-mail: dgc@ksu.edu)

Many of the issues associated with ongoing global climate change hinge on the impacts of the documented physical changes (e.g., rising temperature) on the ecological systems that sustain life. Soil is a primary interface between the two. Most GCM forecasts indicate that increasing temperatures will result in increasing evaporation rates and an increase in drought occurrence. Although ongoing measurements are demonstrating climate change, little information is available concerning corresponding changes in soil water. We analyze 32 years of soil water content data collected at five sites over a 1,000 m elevation gradient in terms of changes in plant water stress. Each soil monitoring site is associated with a long-term weather station and documented climate change. We found that the documented air temperature change of approximately one degree has little impact on soil water dynamics. This is probably because precipitation, which has remained constant, introduces a large noise signal. The impacts of climate change on soil water will most likely be expressed first in under areas with a seasonal snow cover (higher elevations).

Using Soil Moisture Trends Across Topographic Gradients to Examine Controls on Ecosystem Dynamics in a Semi-arid Watershed

[*T J Smith*] (Department of Geosciences, Boise State University, 1910 University Drive, Boise, ID 83725-1535, phone 208-426-1631, fax 208-426-4061, e-mail ToniSmith@u.boisestate.edu); M L Kunkel; S G Benner; J P McNamara; M M Gribb (Department of Geosciences, Boise State University)

The Dry Creek Experimental Watershed near Boise, Idaho is characterized by a dramatic ecological gradient from grasslands near 1000 m to conifer forests near 2100 m elevation. Even at a single elevation, such steep ecological gradients are observed across a change from south to north aspect. We hypothesize that ecosystem dynamics in this semi-arid environment are controlled by a limited period of high ecological activity produced by elevated soil moisture and temperature conditions. By monitoring soil moisture behavior at different elevations and aspects, we examine how the duration and timing of spring soil moisture availability relates to ecosystem functioning and carbon cycling. During spring, slopes receiving about 20 percent less solar insolation (north aspects) contain approximately twice as much soil water as slopes subject to higher radiation input (south aspects). North-facing slopes also exhibit delayed spring dry down, with plant-available water enduring about 2 weeks longer than in south-facing slopes. This prolonged availability of soil moisture during the warm season can cause seven times as much seasonal primary productivity (as inferred from plant area index) on north compared to south aspects. The topographic trends in soil moisture availability correspond closely with trends in soil carbon content; the concentration of soil carbon increases by a factor of seven over a 600 m elevation gradient, and by a factor of ten on north versus south aspects. Furthermore, measurements of soil respiration indicate that a rise in soil moisture produced by one warm-season precipitation event can increase the seasonal carbon efflux from soils by about 25 percent. Our observations indicate that ecological processes in the Dry Creek Experimental Watershed are temperature- limited during winter and moisture-limited during summer, but that elevated soil moisture and temperature conditions combine during a brief period in spring to produce peak carbon cycling activity. We posit that the duration of ideal moist-warm soil conditions dictates the magnitude of above- and below-ground carbon storage. According to our observations, changes in the timing and duration of the moist-warm period, such as climatic shifts toward earlier or later snowmelt or a change in the frequency of early summer rains, would strongly impact the carbon storage potential of semi-arid ecosystems.

Role of Large-Scale Forest Restoration Treatments on the Ecohydrology of Semi-Arid Catchments

[*A E Springer*] (School of Earth Sciences and Environmental Sustainability, Northern Arizona University, Northern Arizona University, AZ 86011-4099; ph 928-523-7198; fax 928-523-9220; e-mail: abe.springer@nau.edu); W W Covington (Ecological Restoration Institute, Northern Arizona University, Flagstaff, AZ 86011; ph 928-523-6635; fax 928-523-0296; e-mail: W.Wallace.Covington@nau.edu)

Large-scale forest restoration treatments of forest thinning and return of fire are being planned for the ponderosa pine (Pinus ponderosa) forests spanning at least four forests of U.S. Forest Service land in Arizona. This proposed action is part of the greater Four Forests Partnership and Statewide Strategy for Restoring Arizona's Forests. In the arid and semi-arid Western U.S., these upland forests play an important role in the health and sustainability of watersheds. They provide not only an important resource for their woody forest products, but for the role they play in managing recharge and runoff to aquifers and streams. Hence, it is important that any management changes to these forests, including large-scale restoration, is informed by the affects these management changes will have to watersheds. Riparian ecosystems within these forested watersheds are rare and comprise only about 1 % of the total land area, but support a much larger portion of the region's biodiversity. It is imperative to design forest restoration for the benefit of the functions the watersheds provide to local and downstream surface-water and groundwater users, including the instream users, such as the riparian ecosystem and recreation. The removal of herbaceous biomass with fire and thinning can reduce transpiration and increase soil water content. Previous

studies have indicated both increases and decreases in soil-water content after prescribed burning. Long-term monitoring plans are being designed to assess the success of the restoration treatments.

Stable Hydrogen and Oxygen Isotopes in Precipitation in Linze, Northwestern China: Influence of Local Moisture Recycling and Secondary Evaporation

[*Z Sun*] (School of Environmental Studies, China University of Geosciences, Wuhan 430074, China; ph. 86-27-67883152; fax 86-27-67883152; Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843-2126; ph. 979-845-4569; fax 979-845-643; e-mail:ziyong.sun@gmail.com); A Zhou (School of Environmental Studies, China University of Geosciences, Wuhan 430074, China; ph. 86-27-67883060; fax 86-27-67885047; e-mail: aiguozhou@cug.edu.cn); S Yu (School of Environmental Studies, China University of Geosciences, Wuhan 430074, China; ph. 86-27-67883472; fax 86-27-67885047; e-mail: yshw621@126.com)

Event-based precipitation samples were collected from June 2008 to February 2009 in Linze, Gansu, China for analyzing the stable isotope ratios of hydrogen (2H/1H) and oxygen (18O/16O). The results show that the amount-weighted average δ2H and δ18O values of precipitation were -37.4‰ and -6.6‰, respectively. Consistent with International Atomic Energy Agency (IAEA) established practice, the local meteoric water line (LMWL) for Linze, δ2H = 7.79δ18O + 15.2 (r2 = 1.0, n = 8), was derived using amount-weighted monthly average δ2H and δ18O values. The correlation equation between δ2H and δ18O values from individual samples was found to be δ2H = 7.30δ18O + 5.66 (r2 = 0.96, n = 28), which is different from the LMWL, exhibiting lower slope value and higher intercept value. Besides a clear seasonality with lower δ2H and δ18O values in snow samples and higher values in rain samples, an abrupt decline of δ2H and δ18O values for rain samples in late July was observed. The δ2H andδ18O values in rain samples before 28 July were 0.2‰~43.1‰ and –0.9‰~4.8‰, respectively, which were much more 'positive' than those in rain samples after 28 July (δ2H: – 6.1‰ ~ –82.1‰; δ18O: – 1‰ ~ – 11.9‰). A marked amount effect was also found in this study. For small amount rain events (< 1 mm), the correlation between δ2H and δ18O was δ2H = 7.55δ18O + 0.29 (r2 = 0.95, n = 10). For more intense rain events (> 1 mm), it was found to be δ2H = 7.61δ18O + 12.12 (r2 = 0.97, n = 14), closer to the LMWL. The δ18O and δ2H temperature dependences at Linze were 0.71‰/oC and 4.97‰/oC, respectively, greater than the global values based on monthly average temperature. These isotopic characteristics of precipitation may be attributed to the incorporation of inland recycled moisture into clouds and secondary evaporation during precipitations. Our data suggest that the moisture derived from local evapotranspiration contributes greatly to the precipitation in Linze in dry season. This study shows event-based sampling of precipitation yields valuable information, which is missed when using monthly composite samples.

Hydrologic Impacts of Vegetation Treatments Within Bates Creek Watershed, Wyoming

[*Aaron N. Swallow*] (Department of Renewable Resources, University of Wyoming, Laramie, WY 82071; ph. 307-256-7022; fax: 307-766-6403; email: aswallow@uwyo.edu); Ginger B. Paige (Department of Renewable Resources, University of Wyoming, Laramie, WY 82071; ph. 307-766-2200; fax: 307-766-6403 email: gpaige@uwyo.edu)

The Bates Creek watershed project site is located in central Natrona County, Wyoming. The Wyoming Game and Fish Department, Casper Region, is currently using prescribed fire in Wyoming big sagebrush (Artemisia tridentata wyomingensis) communities to improve forage conditions for elk, mule deer and livestock. Conifer removal with a tractor

mounted mulcher is being used to set back succession in conifer- encroached quaking aspen (Populus tremuloides Michx.) communities to historic conditions. The short and long term hydrologic impacts of these vegetation treatment methods are difficult to quantify and the research results are often conflicting. This project will increase the knowledge base regarding the impacts of vegetation manipulation projects in aspen and sagebrush communities and their potential effects on hydrologic function. This will be accomplished through: 1) nested instrumentation at critical areas of the watershed 2) integrating existing and future watershed, climate and hydrologic data into a spatial database; 3) conducting small plot rainfall simulations on the wood mulch by-product of the conifer removal treatments; and 4) development of a framework for a Geographic Information Systems (GIS) hydrologic model interface such as GeoWEPP. Preliminary climatic, precipitation, hydrologic function data, and sample GeoWEPP model runs will be presented.

Runoff and Erosion Dynamics on Semi-arid Rangelands in Central Texas: Influence of Scale and Disturbance

[*Min-cheng Tu*] (Water Management and Hydrologic Science Program, Texas A&M University, College Station, TX 77843; ph. 412-867-5604; e-mail: mct1976@tamu.edu); Bradford Wilcox (Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843; ph. 979-458-1899; fax 979-845-6430; e-mail: bwilcox@tamu.edu); William Fox (Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843; ph. 979-458-3315; e-mail: w-fox@tamu.edu)

The influence of scale and disturbance on runoff and erosion from rangelands is poorly understood, partly because long-term and multiple scale watershed data are limited. In this study, we took advantage of the data collected from 33 sub-watersheds of the Cowhouse Creek in central Texas for the past 15 years. Sizes of these sub-watersheds range from less than one hectare to one hundred forty thousand hectares, and they have been experienced different types and magnitudes of human disturbance. We anticipate to find a threshold, or critical size, of the watershed area that the hydrologic response drastically changes beyond the threshold. We also would like to see how human disturbance influences the threshold. In the end, we plan to propose a numerical relation between these factors.

A Theoretical Approach to Urban Ecohydrology: Incorporating the Role of Humans as Engineers of Ecosystem Change

[L Turnbull] (Global Institute of Sustainability, Arizona State University, PO Box 875402, Tempe, AZ 85287-5402, USA); D.L Childers (Global Institute of Sustainability & School of Sustainability, Arizona State University, PO Box 875402, Tempe, AZ 85287-5402, USA); N.B. Grimm (School of Life Sciences, Arizona State University, PO Box 874501, Tempe, AZ 85287-5402).

In this study, we define urban ecohydrology as the structural and functional components that derive the biotic-abiotic complex which controls hydrological processes within the urban ecosystem. To translate the notion of ecohydrology to urban ecosystems, it is imperative to explicitly consider humans as an intrinsic component of these systems, in which humans are the primary engineers of ecosystem change. In the rapidly growing urban ecosystems of the southwestern USA, such as the Phoenix metropolis, humans have had a significant effect upon ecosystem processes; in particular, by modifying hydrologic regimes and the spatial heterogeneity of biotic-abiotic components of the ecosystem.

In this study, we conceptualize ecohydrological interactions within the arid urban environment, focussing the role of humans as ecosystem engineers. We explore how human modifications to the urban ecosystem affect interactions between biotic and abiotic processes and, seek to determine how humans as ecosystem engineers alter hydrological processes and the resulting changes in spatial and temporal scales over which ecohydrological interactions occur. We present a comparative study of three catchments (Sycamore Creek, Cave Creek and Indian Bend Wash), that have experienced different degrees and types of human engineering of the ecosystem. Results of exploratory analyses indicate that differences in ecohydrological feedbacks between catchments are most pronounced for smaller rainfall events. In Indian Bend Wash, the significant engineering of the ecosystem greatly reduces flow connectivity through main drainage lines. For larger runoff events, the ecosystem at Indian Bend Wash is well connected, yielding a hydrological response that is more comparable to the hydrological response of Sycamore Creek and Cave Creek.

Headwater Catchments: Linking Aquatic Ecology, Hydrology and Habitat Recovery in a Changing Climate

[*Scott W. Tyler*](University of Nevada, Reno, Reno, Nevada,775-784-6250, 775-784-1953, styler@unr.edu); Christine Hatch (University of Nevada, Reno, Reno, Nevada,775-784-4509, 775-784-1953, chatch@unr.edu); Laura Belica (National Park Service, Great Basin National Park, Baker, Nevada, 775-234-7331, Laura_Belica@nps.gov); David Prudic (University of Nevada, Reno, Reno, Nevada, 775-784-1111, 775-784-1953, prudic@unr.edu) Michael Singleton (Lawrence Livermore National Laboratory, Livermore, California, 925-424-2022, msingleton@llnl.gov)

Headwater catchments in semi-arid regions often represent the remaining refuges for native and endemic aquatic species. Contrary to the more developed and exploited water resources of the lower elevation reaches of catchments, these headwater streams either still support native fisheries, or hold the promise to be "restorable" to the pre-development ecosystem. A key ecological and hydrologic indicator of mountain streams is temperature. The thermal regime of high altitude catchments, in particular the daily and annual cycles, as well as the spatial variability of temperature, often define the distribution and viability of aquatic species. There also exists strong feedbacks between the thermal regime of mountain streams and both the vegetation distribution and the subsurface flow path distributions. In the past, measurements of stream temperatures were very limited in both space and time. With the application of fiber-optic distributed temperature sensing, it is now possible to obtain synoptic sampling of in-stream temperatures remotely, and throughout the year. We present data from three semi-arid catchments (Strawberry Creek in the Great Basin, Squaw Creek the Sierra Nevada, and Horse Creek in the coastal range of California.) to investigate the seasonality of thermal behavior, the feedback between hydraulics and ecosystem function, and most importantly, the identification and spatial variability of thermal refugia. We further discuss the role of climate change on these diverse catchments and the implications of early season melting and enhanced early season runoff on the maintenance of thermal refuges.

Effects of Annual and Ephemeral Plants on Carbon and Water Cycling in a Riparian Ecosystem and a Sonoran Desert Upland

[*A P Tyler*] (Ecology and Evolutionary Biology/B2 Earthscience, University of Arizona, Tucson, AZ 85721; ph. 520-621-8220; fax 520-621-9190; email: atyler@email.arizona.edu); R S Scott (Southwest Watershed Research Center, USDA-ARS, 2000 E. Allen Rd., Tucson, AZ 85719; ph. 520-670-6380; fax 520-670-5550; e-mail: russ.scott@ars.usda.gov); T E Huxman (Biosphere 2, B2 Earthscience, Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ, 85721; ph. 520-626-4092; fax 626-0793; email: huxman@email.arizona.edu)

Changes in vegetation structure in pulse-driven, water-limited systems can have important and non-linear affects on ecohydrological and biogeochemical cycles. We have studied the impacts of seasonally present annual and ephemeral herbs on ecosystem processes in two systems within a semiarid region of SE Arizona: a riparian system with woody plant encroachment and a true Sonoran Desert upland. In both systems the herbaceous plants are present and active only during periods of optimal resource availability. Although their standing biomass is small compared to the dominant perennial plants, ephemeral herbs represent seasonal bursts of increased activity and primary production disproportional to their standing stock. For example, in an encroached riparian woodland, ephemeral herbs can fill in 70% of the understory with plants 1m in height and an average leaf area index of 2.5 in response to summer monsoon precipitation. We found that given this increase in aboveground photosynthetic biomass, annual and ephemeral herbs at their peak seasonal activity have a significant contribution to this ecosystem's carbon and water exchange. In the Sonoran Desert upland, we found that the presence of winter annual plants can significantly affect a long-lived perennial shrub's access to shallow soil moisture, and constrain the shrub's photosynthetic gas exchange. In both a riparian setting and a desert upland, annual and ephemeral herbs affected coupled carbon and water exchanges between soils, vegetation and the atmosphere. Study of the ephemeral components of ecosystems is important to our understanding of the ecology of these systems, how they affect and interact with biotic and abiotic controls of carbon and water cycling, and to improve our estimates of the components of ecohydrological fluxes given shifts in physiognomy and climate.

Evapotranspiration Partitioning Along Gradients of Tree Cover: Ecohydrological Insights From Experimental Evaluation In The Biosphere 2 Glasshouse Facility

[*J C Villegas*] (School of Natural Resources, Biosphere 2, University of Arizona, Tucson, Az, 85721. Universidad de Antioquia, Medellín, Colombia; ph. 520-626-7131; Fax: 520-621-8081 e-mail: villegas@email.arizona.edu); G Barron-Gafford (Ecology and Evolutionary Biology, Biosphere 2, University of Arizona, Tucson, Az, 85721; ph. 520-626-4092; Fax: 520-626-0793; e-mail: gregbg@email.arizona.edu); H A Adams (Ecology and evolutionary biology, Biosphere 2, University of Arizona, Tucson, Az, 85721. ph. 520-626-4092; Fax: 520-626-0793; email: henry@email.arizona.edu); M Guardiola-Claramonte (Hydrology and Water resources, Biosphere 2, University of Arizona, Tucson, Az, 85721. ph. 520-626-4092; Fax: 520-626-0793; email: maite@hwr.arizona.edu); E Sommer (Biosphere 2, University of Arizona, Tucson, Az, 85721. ph. 520-626-4092; Fax: 520-626-0793; email: sommerevan@gmail.com); A Wiede (Biosphere 2, University of Arizona, Tucson, Az, 85721. ph. 520-626-4092; Fax: 520-626-0793; email: ashley@email.arizona.edu); D D. Breshears (School of Natural Resources, Ecology and Evolutionary Biology, Biosphere 2, University of Arizona, Tucson, Az, 85721. ph. 520-626-7131; Fax: 520-621-8081 e-mail: daveb@email.arizona.edu); C B Zou (Natural Resource Ecology and management, Oklahoma State University, Stillwater, Ok, 74077; ph: 405-744-9637; Fax: 405-744-3530; email: chris.zou@okstate.edu); J Espeleta (Biosphere 2, University of Arizona, Tucson, Az, 85721. ph. 520-626-4092; Fax: 520-626-0793; email: espeleta@email.arizona.edu); T E Huxman (Ecology and Evolutionary Biology, Biosphere 2, University of Arizona, Tucson, Az, 85721; ph. 520-626-4092; Fax: 520-626-0793; e-mail: huxman@email.arizona,edu)

Many ecosystem processes and properties are driven by ecohydrological feedbacks imposed by changes in the proportion of woody plants in the landscape. Such variability in woody plants is particularly relevant in drylands where the presence and distribution of woody plants affect key processes such evapotranspiration, the largest component water budget. Yet, lacking is a description of how the two major components of evapotranspiration, soil evaporation and transpiration from plants, respond individually to changes in the amount of woody plant cover in response to microclimatic feedbacks associated with the presence and proportion of woody plants. We developed an experiment at Biosphere 2, where we simulated different levels of canopy cover by establishing regular 10 x 10 arrangements of containers with either bare soil or a mesquite tree (Prosopis chilensis) approximately 2.5 m tall. A pulse of moisture was added to each container and water loss from individual containers was monitored. Total evapotranspiration was calculated as the integration of water loss from individual containers. Containers with bare soil were sources of evaporation, while containers with trees were sources of evapotranspiration, discriminated by the installation of sap flow sensors in the trees. Our results illustrate how the partitioning of evapotranspiration at the landscape scale responds in a non-linear way to changes in vegetation cover though a density-dependent feedback that can be explained by the local-scale microclimatic effects of woody-plant cover. Our experiments, which used the unique logistical capabilities of the Biosphere 2 glasshouse facility, highlight the systematic and interactive effects of canopy cover and along gradients of vegetation cover in hydrological variables that influence ecosystem processes and properties. More generally, our results provide important insights for the description of relevant ecohydrological processes in gradients of increasing tree cover, such as those occurring in elevational gradients on drylands.

Catchment Patterns and Controls on Soil Moisture and Evapotranspiration in a Mountainous Basin within the North American Monsoon Region

[*E R Vivoni*] (School of Earth and Space Exploration & School of Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ 85287-1404; ph. 480-965-5081; fax 480-965-8102; e-mail: vivoni@asu.edu); C J Watts (Departmento de Fisica, Universidad de Sonora, Hermosillo, Sonora, Mexico 83100; email: cwatts@correo.fisica.uson.mx); J C Rodriguez (Departamento de Agricultura y Ganaderia, Universidad de Sonora, Hermosillo, Sonora, Mexico 83100; email: jcrod@raramuri.fisica.uson.mx)

In the North American monsoon (NAM) region, in-phase seasonality in precipitation and radiation should lead to corresponding changes in the catchment hydrologic response and its spatiotemporal variability. Nevertheless, relatively little is known on the catchment response in the NAM region due to the paucity of observations. Numerical watershed models, tested against field and remote sensing data, can aid in identifying catchment hydrologic patterns and the controls exerted by climate, soil, vegetation, and terrain properties. In this study, we utilize a distributed hydrologic model to explore the soil moisture and evapotranspiration distributions in a semiarid mountain basin. Results indicate a reliable and consistent model performance at the point and catchment-scales for a set of tested hydrologic states and fluxes. Distributed model simulations reveal that soil, vegetation, and terrain controls on catchment spatial patterns vary according to the wetness state in a manner similar to that found across a wider range of climate conditions. Spatiotemporal variations in soil moisture and evapotranspiration also exhibit hysteresis as an emergent pattern induced by climate variability and the underlying hydrologic interactions in the catchment.

Ecohydrological Interactions During Vegetation Change in the Southwestern USA

[J Wainwright] J Wainwright (Department of Geography, University of Sheffield, Winter Street, Sheffield, S10 2TN, UK); L Turnbull (Global Institute of Sustainability, Arizona State University, PO Box 875402, Tempe, AZ 85287-5402, USA); R.E. Brazier (Department of Geography, University of Exeter, Amory Building, Rennes Drive, Exeter, EX4 4RJ, UK)

It is widely acknowledged that semi-arid vegetation change, such as transitions from grassland to shrubland, are characterized by rapid shifts in community structure. However, little is known about the changes in ecohydrological feedbacks and interactions during the process of shrub encroachment into grassland. In this study we investigate changes in biotic and abiotic structural and functional components of the ecosystem at stages over a gradient of Larrea tridentata encroachment into Bouteloua eriopoda grassland at the Sevilleta Long Term Ecological Research site, NM, which provides a spatial analogue for the temporal dynamics of vegetation change.
Results of the study show distinct spatio-temporal variations in soil-moisture content at stages over the transition from grassland to shrubland, which are due to the net effect of processes operating at multiple spatial and temporal scales, such as plant uptake of water at local scales versus the redistribution of water during runoff events at the hillslope scale. There is an overall increase in runoff over the transition from grassland to shrubland, which is associated with an increase in connectivity of bare, runoff-generating areas. However this increase in runoff does not appear to follow a linear trajectory, since the greatest amount of runoff was measured prior to full shrub domination (when some grass 'patches' are still persistent in the landscape). Erosion rates progressively increase over the transition from grassland to shrubland, related in part to changes in runoff characteristics but also to changes in the spatial distribution of vegetation and soil characteristics over the transition. The increase in erosion over the transition from grassland to shrubland, in combination with the selective erosion of fine sediment, is particularly significant in terms of nitrogen and phosphorus losses during runoff events and therefore plant-nutrient availability. Ecohydrological interactions during this transition from grassland to shrubland are very tightly coupled, such that the shift in community structure and concurrent shift in the underlying abiotic regime of the ecosystem (prior to full shrub domination) result in a shift in ecosystem state which is likely to be irreversible in the short-medium term.

Refining the Partitioning of Evapotranspiration as a Function of Woody Plant Cover Continuous Stable Isotope Monitoring Provides Bridge from Glasshouse to Field Conditions

[*Lixin Wang*] (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ, 08544; ph. 609-258-8308; fax 609-258-2799; email: lixinw@princeton.edu); Kelly K. Caylor (Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ, 08544; ph. 609-258-4614; fax 609-258-2799; email: kcaylor@princeton.edu): Juan C. Villegas (School of Natural Resources, University of Arizona, Tucson, AZ 85721; ph. 520-621-7259, fax: 520-621-8081; email: villegas@email.arizona.edu); David D. Breshears (School of Natural Resources, University of Arizona, Tucson, AZ 85721; ph. 520-626-7131; fax: 520-621-8081; email: daveb@email.arizona.edu)

In water-limited ecosystems, one of the most important ecohydrological challenges is to understand the partitioning of evapotranspiration fluxes (e.g., plant transpiration and soil/canopy evaporation). Current changes in land use and vegetation cover at landscape to ecosystem scales will likely affect these fluxes, therefore hastening the need to better understand the dynamics and the controlling factors of evapotranspiration partitions. In particular, lacking are studies that evaluate how evapotranspiration partitioning changes systematically with increasing woody plant covers, which is important because this is a fundamental landscape pattern. Related research at the Biosphere 2 glasshouse facility is addressing this issue (see Villegas et al., this meeting) but ways to bridge the glasshouse study to the field scale observations are rare. In this study, we used an experimental set-up at the Biosphere 2 glasshouse facility to develop and evaluate a monitoring technique using a newly-developed laser-based isotope analyzer to continuously monitor the partitioning of evapotranspiration into evaporation from the soil and transpiration from plants. Our results support other observations from controlled experiments which indicate that the partitioning of evapotranspiration varies non-linearly with changes in vegetation cover. Notably, our technique, which can be implemented under field conditions, has the potential of expanding such results and producing direct and continuous estimations of evapotranspiration partitioning at the ecosystem scale. These results highlight the potential use of high resolution δ2H flux measurements as an important tool to address key ecohydrological challenges, such as the partitioning of evapotranspiration fluxes in water-limited ecosystems.

Effects of latitudinal gradient in surface characteristics over the North American Monsoon core region

[*C J Watts*] (Departmento de Fisica, Universidad de Sonora, Hermosillo, Sonora, Mexico 831000; Tel: (52) 662 259 2108; Fax: (52) 662 259 2109; email: christopher.watts@correo.fisica.uson.mx); Carlos Lizarraga (Departmento de Fisica, Universidad de Sonora, Hermosillo, Sonora, Mexico; email: clizarraga@gmail.com); J C Rodriguez (Departamento de Agricultura y Ganaderia, Universidad de Sonora, Hermosillo, Sonora, Mexico; email: jcrod@raramuri.fisica.uson.mx); Russell Scott (Southwest Watershed Research Center, USDA-ARS, Tucson, Az 85025; email: Russ.Scott@ARS.USDA.GOV)

The surface characteristics for six locations in western Mexico and southwestern US (from Jalisco, Mexico to Arizona, USA), that lie within the North American Monsoon (NAM) region are analyzed using available MODIS satellite data, with supplementary surface instrumental data for two of these sites. The analysis for each site is carried out for the period 2000-2008, that includes all available MODIS data. A comparison of seasonal and annually variability in surface conditions for EVI, albedo and LST at each site is presented, with a more detailed analysis for the Rayón and Rosario de Tesopaco sites using available surface data from field observations. The qualitative behavior and climate response of three types of vegetation (desert shrub, subtropical shrub, and tropical deciduous forest vegetation) are analyzed under the influence of the North American Monsoon summer wet season. The onset of the Monsoon warm wet season in early summer, is one of the main precursors of generalized EVI growth in all the NAM region. At all the sites, it is observed that the mean daytime LST cools several degrees as the Monsoon fully develops. During the warm wet season, in the case of open and sparse vegetation regions such as desert shrub and subtropical shrub, albedo values fall slightly during the Monsoon season, while in closed and dense tropical deciduous forest regions albedo shows a slight increase. Additionally it is found that, desert shrub and subtropical shrub regions in northern latitudes show large LST and small EVI (albedo) seasonal variability, whilst tropical deciduous forests in southern latitudes show much larger EVI (albedo) and smaller LST seasonal variability. Thus MODIS data proves to be a valuable tool in assessing spatio-temporal response of surface characteristics under a determinate climate pattern.

Woody Plant Encroachment Paradox: Rivers Rebound as Degraded Grasslands Convert to Woodlands

[*B.P. Wilcox*] (Ecosystem Science and Management, Texas A&M University, College Station, Texas 77843; ph. 979-458-1899; fax 979-845-6430; e-mail: bwilcox@tamu.edu); Yun Huang (LBG Guyton, Austin, Texas; ph 512-327-9640: email yhuang@lbg-guyton.com)

The related phenomena of degradation and woody plant encroachment have transformed huge tracts of semiarid and subhumid rangelands. This transformation may have enormous consequences for regional water supplies, but to date few assessments have been done at scales larger than that of small catchments. Woody plant encroachment in particular is assumed to reduce groundwater recharge and, hence, baseflow to streams. For the study reported on in this paper, we analyzed the long-term (85 years) streamflow trends of four major river basins in the Edwards Plateau region of Central Texas. This region, in which springs are abundant because of the karst geology, has undergone both degradation and woody plant encroachment. We found that, contrary to common and widespread perceptions, streamflows have not been declining. In fact, the contribution of baseflow (supplied by springs and groundwater) has doubled—even though woody plant cover has expanded and rainfall amounts have remained relatively constant. We attribute this increase in springflow to a general landscape recovery that has taken place concurrent with woody plant expansion—a recovery brought about by lower grazing pressure and improved land management. Our results indicate that for drylands where the geology supports springs, it is degradation and not woody plant encroachment that leads to regional-scale declines in groundwater recharge and baseflows. Further, our results indicate that when woody plant expansion follows on the heels of degradation, it may even help reverse these declines.

The Isotopic Signature of Water Vapor, Leaf Water and Transpiration in Mixed Conifer Forest

[*David D G Williams*] (Departments of Renewable Resources and Botany, University of Wyoming, Laramie, WY 82071; ph. 307-766-2494; e-mail: dgw@uwyo.edu); B E Ewers (Department of Botany, University of Wyoming, Laramie, WY 82071; ph. 307-766-2625; e-mail: beewers@uwyo.edu); J L Angstmann (Department of Botany, University of Wyoming, Laramie, WY 82071; ph. 307-766-2380; e-mail: jangstma@uwyo.edu); B Massman (Rocky Mountain Research Station, US Forest Service, Fort Collins, CO 80526; ph. 970-498-1296; e-mail: wmassman@fs.fed.us); J Frank (Rocky Mountain Research Station, US Forest Service, Fort Collins, CO 80526; ph. 970-498-1319; e-mail: jfrank@fs.fed.us)

The stable isotope signature of ecosystem water pools and fluxes provides insight into the partitioning of precipitation inputs into evapotranspiration, runoff and deep drainage and is an important indicator and integrator of environmental change. The isotopic signatures of leaf water and water vapor in canopy air are key variables in models that relate hydrogen and oxygen stable isotope ratios in tree ring cellulose to hydrological and climate changes and plant physiological response. Accounting for isotopic non-steady state transpiration is potentially important in these applications, but the magnitude and spatio-temporal patterns of transpiration at isotopic non-steady state in forest trees are poorly characterized. Low rates of leaf gas exchange in some tree species, especially conifers, are associated with low leaf-water turnover rates, which greatly extends the time required to achieve transpiration at isotopic steady state as environmental conditions change over diurnal periods. Leaf longevity is also quite high (ca. 6-10 yrs.) in many evergreen coniferous species and stomatal conductance and rates of leaf gas exchange tend to decline as leaves age in conifer stands. We measured hydrogen and oxygen stable isotope ratios of water in leaves of different ages and from different vertical canopy positions in sub-alpine fir (Abies lasiocarpa) and Engelmann spruce (Picea englemannii) over two separate diurnal periods during the growing season of 2008 in high elevation, mixed coniferous forest at the USFS Glacier Lakes Ecosystem Experiments Site (GLEES) in the Snowy Range of southeastern Wyoming, USA. We collected needles every 3-4 h over 24-h periods to investigate the dynamics of leaf water isotopic enrichment. Concurrent measurements of leaf gas exchange and leaf water content allowed us to model the leaf water turnover rate and the isotope ratio of transpiration in the non-steady state. Daily patterns of transpiration determined from sapflux measurements agreed with patterns of leaf conductance and transpiration determined from leaf-level by gas exchange measurements. Stomatal closure during hot, dry afternoon periods reduced leaf and tree level transpiration and leaf water turnover rates. Atmospheric water vapor was collected also every 3-4 h for isotopic analysis at multiple heights within and above the canopy. The isotopic composition of water vapor in the forest canopy became enriched in the heavy isotopes of hydrogen and oxygen during midday periods relative to that during early morning and nighttime periods reflecting an increased contribution of transpired water vapor to canopy air at midday. Keeling plot analyses suggested that the isotopic composition of the evapotranspiration flux was not constant during daytime periods, potentially reflecting changes in the isotope ratio of forest transpiration associated with transpiration at isotopic non-steady state. We conclude that modeling the isotope composition of forest transpiration and leaf water to increase predictive understanding of evapotranspiration should take into account the variation in leaf water turnover rates associated with leaf age and canopy position.

Hydrologic Impacts of Soil Water Repellency on Fine- to Coarse-Textured Soils of Wooded Shrublands and Shrub-Steppe Communities

[*C J Williams*], (USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Ste 105, Boise, ID 83712; ph. 208-422-0700; fax 208-334-1502; e-mail: jason.williams@ars.usda.gov); F B Pierson (USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Ste 105, Boise, ID 83712; ph. 208-422-0700; fax 208-334-1502; e-mail: fred.pierson@ars.usda.gov); P R Kormos (USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Ste 105, Boise, ID 83712; ph. 208-422-0700; fax 208-334-1502; e-mail: patrick.kormos@ars.usda.gov); O Al-Hamdan (USDA-ARS Northwest Watershed Research Center, 800 Park Blvd., Ste 105, Boise, ID 83712; ph. 208-422-0700; fax 208-334-1502; e-mail: osama.al-hamdan@ars.usda.gov)

The potential for soil water repellency to dominate rangeland hydrologic responses has significant implications for ongoing plant community transitions and disturbance regimes. Naturally occurring soil water repellency has been well documented on semiarid rangelands and chaparral plant communities. Soil water repellency occurs in fine- to coarse-textured unburned soils due to the coating of soil particles with hydrophobic compounds leached from organic materials. Burning can induce or exacerbate soil water repellency where volatized hydrophobic compounds are translocated into the soil profile. The hydrologic effects of soil water repellency under unburned conditions are largely dampened by canopy interception, surface retention of runoff, and heterogeneous infiltration patterns. Vegetation and ground cover alterations following disturbance greatly reduce these mitigating effects. We present a culmination of hydrologic data from several sagebrush sites and two pinyon and juniper invaded shrublands under undisturbed and disturbed conditions. We demonstrate how the spatial arrangement of vegetation influences soil water repellency and runoff behavior and present examples of post-disturbance hydrologic responses to vegetation change on water repellent soils. We further show that the temporal variability in the strength of soil water repellency greatly affects hydrologic responses to disturbances. We conclude by speculating on the potential hydrologic impacts of soil water repellency following plant community transitions and altered disturbance regimes.

Modeling Wind Speed and Snow Accumulation Gradients Over Complex Terrain From Typically Collected Meteorological Data

[*A Winstral*](USDA-ARS Northwest Watershed Research Center, Boise, ID 83712; ph. 208-422-0739; e-mail: adam.winstral@ars.usda.gov); D Marks (USDA-ARS Northwest Watershed Research Center, Boise, ID 83712; ph. 208-422-0721 e-mail: ars.danny@gmail.com); R Gurney (ESSC, University of Reading, Reading, UK RG6 6AL; e-mail: rjg@mail.nerc-essc.ac.uk)

Mountain winds exhibit strong gradients over short distances due to the influence of terrain. In winter, the acceleration of wind over wind-exposed slopes and its consequent deceleration over lee slopes strongly influences snow distribution. The heterogeneous snow distribution effects soil moisture, vegetation, effective habitat, and runoff. Capturing these gradients is difficult due to the inherent complexity of wind fields and a general lack of data from high elevation, wind-exposed locations. This study was conducted in the Reynolds Mountain East research basin in southwest Idaho, USA. The basin is uniquely instrumented with a network of wind and snow depth sensors that capture a large range of variability. Manual snow surveys are conducted twice a year to further assess snow distribution. Wind and snow trends in conjunction with detailed terrain analyses were assessed to establish relationships between wind speed, snow accumulation (including the effects of wind-induced redistribution), terrain structure and vegetation. Computationally efficient methods for distributing wind speed and snow accumulation from terrain structure, vegetation and point measurements that do not necessarily capture full gradients were established as part of this study. These methods were used to drive a distributed mass and energy balance snow model with effective results. The developed algorithms have a physical basis and are suitable for assessing the multifaceted hydrologic impacts associated with a changing climate in mountain environs.

Near-Surface Water Content and Carbon Flux in Biological Soil Crust

[*M H Young*] (Division of Hydrologic Sciences, Desert Research Institute, Las Vegas, NV 89119; ph. 702-862-5489; fax 702-862-5427; e-mail: michael.young@dri.edu); L Fenstermaker (Division of Earth and Ecosystem Sciences, Desert Research Institute, Las Vegas, NV 89119; ph. 702-862-5412; e-mail: lynn.fenstermaker@dri.edu); Jianting Zhu (Division of Hydrologic Sciences, Desert Research Institute, Las Vegas, NV 89119; ph. 702-862-5416; e-mail: jianting.zhu@dri.edu)
Carbon flux from biological soil crusts (BSCs) depends in large part on very-near surface water content (0-3 cm depth), which can vary spatially across landscapes depending on soil texture, microsite location and geomorphic placement. The ultimate goal of this study, confined to lower valley floor settings, was to assess carbon flux patterns at the field scale. We simultaneously investigated the inter-relationships among soil water, carbon flux and reflectance spectra of BSC organisms in samples collected in the Mojave and Colorado Plateau. Carbon flux was determined at different wetness levels using a LI-COR 6400 gas exchange instrument with a custom chamber, and spectral response was assessed contemporaneously using an ASD FieldSpec pro (350-2500 nm). Dual-probe heat pulse sensors (DPHP) were then inserted into the BSC sample to measure water. We also examined the dynamics of near surface water content using a data set collected over a two-year period from 48 locations at a field site in Nevada’s Mojave Desert, USA. Spatio-temporal variation of water

content was analyzed using the spatial mean and variance before and after precipitation events and during spring dry downs. In addition, the skewness of the probability density function, and the spatial and temporal stability of water content were assessed. Carbon flux patterns, as anticipated, were highly correlated to soil water content under simulated Spring temperature and light intensity conditions. Water content trends from sensors installed at ground surface showed significant positive skewness, illustrating the short amount of time when water contents were above mean (and residual) levels, and when the BSCs were biologically active. The results highlight the potential for assessing BSC carbon flux with remote sensing and near-surface soil moisture status, thus providing a synoptic, semi-quantitative method for assessing BSC carbon dynamics.

Woody Plant Encroachment and Water Cycle in Mesic Great Plain Grassland

[*C B Zou*] (Department of Natural Resource Ecology and Management, Oklahoma State University, OK 74078; ph. 405-744-9637; fax 405-744-3530; e-mail: chris.zou@okstate.edu); D Turton (Department of Natural Resource Ecology and Management, Oklahoma State University, OK 74078; ph. 405-744-5441; fax 405-744-3530; e-mail: don.turton@okstate.edu); D M Engle (Department of Natural Resource Ecology and Management, Oklahoma State University, OK 74078; ph. 405-744-5615; fax 405-744-3530; e-mail: david.engle@okstate.edu); S D Fuhlendorf (Department of Natural Resource Ecology and Management, Oklahoma State University, OK 74078; ph. 405-744-9646; fax 405-744-3530; e-mail: sam.fuhlendorf @okstate.edu); R Will (Department of Natural Resource Ecology and Management, Oklahoma State University, OK 74078; ph. 405-744-5444; fax 405-744-3530; e-mail: rodney.will@okstate.edu), K Winton (USGS Oklahoma Water Science Center, OK 73116; ph. 405-810-4417; fax 405-843-7712; e-mail: kwinton@usgs.gov)

Land based water cycle and water supplies to streams and groundwater are heavily influenced by vegetation and vegetation change. In the Great Plains, tallgrass prairie is rapidly transforming to woodland by the encroachment of eastern redcedar trees (Juniperus virginiana) , a process that may significantly alter streamflow and raw water supplies in the Great Plains states where water shortages are increasing. However, our understanding of the ecohydrological impact of woody plant encroachment is mainly from studying semiarid savanna ecosystems, and little is known for more mesic ecosystems like the tallgrass prairie. A field-based, multiple-year collaborative research effort to develop an improved understanding of the ecohydrological impact of eastern redcedar encroachment in tallgrass prairie with a focus on water cycle will be presented and some preliminary results will be discussed.