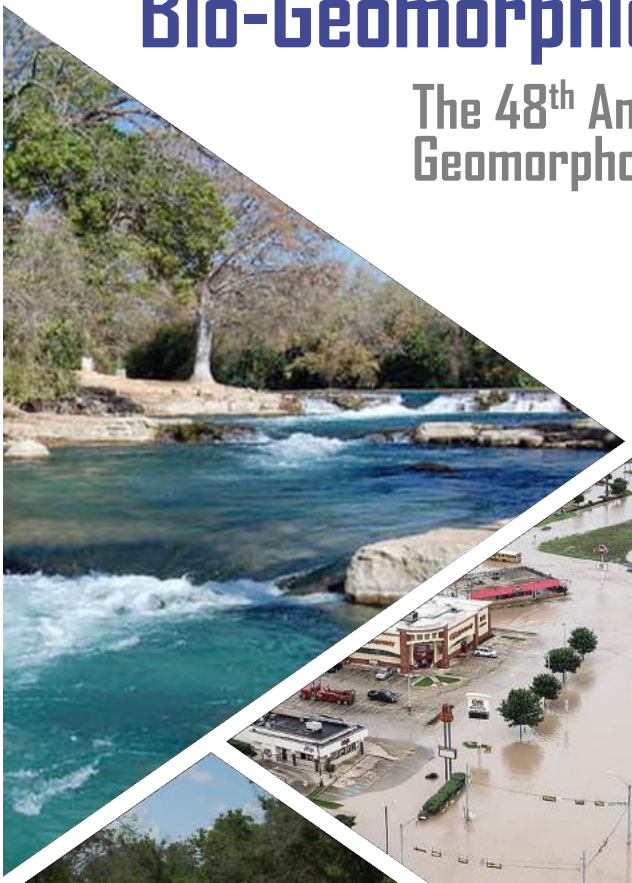
Resilience and Bio-Geomorphic Systems

The 48th Annual Binghamton Geomorphology Symposium



OCTOBER 13-15, 2017

Texas State University
San Marcos, TX

Program designed by Maël Le Noc, Texas State University

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symposium overview

Resilience thinking is a rapidly emerging concept that is being used to frame how we approach the study of biophysical systems. It also seeks to determine how societies, economies, and biophysical systems can be managed to ensure resilience; that is, how to maintain the capacity of a system to absorb disturbance. There are strong overlaps between the scientific discipline of geomorphology (the biophysical processes that shape Earth's landscapes) and the concept of resilience. There is however a lack of awareness of the foundations of the former in the emergence of resilience. Thus, resilience is limited and limiting in its application to bio-geomorphic systems. This symposium provides a collective examination of bio-geomorphic systems and resilience that will conceptually advance both areas of study and further cement the relevance and importance of understanding the complexities of bio-geomorphic systems in an emerging world of interdisciplinary research endeavors. The 48th annual Binghamton Geomorphology Symposium on *Resilience and Bio-Geomorphic Systems* brings together leading and emerging scientists in bio-geomorphology and resilience thinking.

history of the Binghamton geomorphology symposium

The Binghamton Geomorphology Symposium (BGS) was first convened in 1970 and has now had 48 successful Symposia, each devoted to a theme within geomorphology. The BGS has traditionally generated a proceedings volume and many of these have been highly influential in their respective subfields of geomorphology. This long, rich history began at the State University of New York, Binghamton, but has ranged far beyond to locations across the USA and abroad.

In 1966, four geomorphologists and physical geographers at the State University of New York-Binghamton, all graduates of A.N. Strahler at Columbia University, began organizing weekly brown-bag lunches and discussing their common interests: geomorphology and water. As the discussions became more focused over the next few years, and with the addition of Marie Morisawa to SUNY-Binghamton in 1970, the group put on the first Binghamton Geomorphology Symposium, focusing specifically on Environmental Geomorphology.

These co-organizers were dismayed at the increasing specialization and compartmentalization that had occurred in the sciences, and noted that many of the intriguing problems in science had become interdisciplinary. Because many problems in environmental science transcend traditional science and cut across scientific disciplines, they viewed the geomorphologist as the surviving generalist in earth science, as being particularly capable to interact in emerging environmental issues. Thus, they convened the first Binghamton Symposium, stating that "This Symposium is the first in what will be an annual symposia series in geomorphology." And so it was. The Binghamton Symposium has been held annually ever since for five decades. Each year the Symposium covers a specific topic as it relates to geomorphology.

The topic of this year's symposium, Resilience in Bio-Geomorphic Systems, reflects the BGS's goal of producing symposia on scientifically important topics. Resilience as a theme in geomorphology has not been previously addressed in the BSG history, and is a logical follow-on to the successful 2016 symposium on Connectivity in Geomorphology.

meeting organizers

Jason P. Julian, *Texas State University*
Kimberly M. Meitzen, *Texas State University*
David R. Butler, *Texas State University*
Martin Thoms, *University of New England, Australia*

Binghamton symposium steering committee

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Michael J. Woldenberg, *University at Buffalo, SUNY*

- This list may not be all-inclusive -

acknowledgements

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Field Trip
Kimberly Meitzen developed and organized the field trip, with help from the following:

Texas State Outdoor Center and University Camp:
John Griffis

TreeFolks, Trees for the Blanco program:
Thais Perkins, Andreina Alexatos

Meadows Center for Water and the Environment:
Andy Sansom, Thom Hardy

Edwards Aquifer Habitat Conservation Plan (EAHCP):
Nathan Pence, Shaun Payne

City of San Marcos:
Melani Howard, Eric Weeks

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David Andresen, Jeanett Bosarge, Paepin Goff, Stacey Haddad, Colin Iliff, Aspen Manning, Grant Moss, Lacey Smith, Killian Sterling, Edward Terr

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schedule overview

Friday, 13 October

8:00 - 17:00	***Fieldtrip***
18:00 - 21:00	Icebreaker at AquaBrew

Saturday, 14 October

All paper sessions are in Evans Liberal Arts 114
Posters are on the first floor of Evans Liberal Arts

7:30 - 8:30	Registration, Coffee, Fruit & Pastries *Evans Liberal Arts First Floor*
8:30 - 8:45	***Welcome and Opening Remarks***
8:45 - 10:15	***Geomorphic Systems & Resilience***
10:15 - 10:30	Break & Snacks
10:30 - 12:00	***Extreme Events, Thresholds, & Resilience***
12:00 - 13:30	Texas BBQ Lunch *Flowers Hall 230* Poster Viewing
13:30 - 15:00	***Eco-Geo Connections & Resilience***
15:00 - 15:15	Break & Snacks
15:15 - 16:15	***Zoogeomorphology & Resilience***
16:15 - 16:45	Invited Posters Introduction
16:45 - 18:00	***Poster Session***
18:00 - 18:30	Walk (with campus tour) or Van to banquet
18:30 - 21:00	***Banquet with after dinner talk*** *City Park Rec Hall*

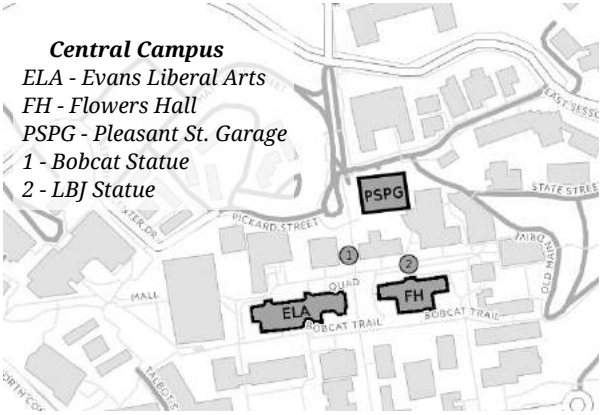
Sunday, 15 October

All paper sessions are in Evans Liberal Arts 114

7:30 - 8:30	Coffee, Fruit & Pastries
8:30 - 10:00	***Coastal Geomorphology & Resilience***
10:00 - 10:15	Break & Snacks
10:30 - 12:00	***Social-Ecological Systems & Resilience***
12:00 - 13:30	***Lunch & discussion of synthesis paper*** *Flowers Hall 230*

maps

San Marcos
1 - Hotels
2 - AquaBrew
3 - Texas State University
4 - City Park Rec Hall



Central Campus
ELA - Evans Liberal Arts
FH - Flowers Hall
PSPG - Pleasant St. Garage
1 - Bobcat Statue
2 - LBJ Statue

field trip

Resilience in the San Marcos and Blanco Rivers from Bio-geomorphic and Social-Ecological Perspectives

Join us for a field trip covering diverse aspects of bio-geomorphic and social-ecological resilience in the San Marcos and Blanco Rivers. This field trip will cover four main topics within this theme, including:

1. Catastrophic flood disturbance on Blanco River from the 2015 Memorial day floods and post-disturbance riparian restoration and recovery, with stops in Wimberley and University Camp on the Blanco River.

2. Restoration of Spring Lake within the Upper San Marcos River watershed, a catered box lunch stop at the Meadows Center for Water and the Environment, and a glass-bottom boat tour of Spring Lake.

3. Overview and examples of instream and riverbank restoration resulting from the Edwards Aquifer Habitat Conservation Plan (EAHCP) on the upper San Marcos River. This portion of the field trip will involve a short kayaking trip of the San Marcos River, however participants not wanting to kayak may choose to walk a paved trail along the river or be transported by the bus to the end point.

4. History, controversy, and removal of Cape's Dam on the San Marcos River.

detailed schedule

FRIDAY, 13 OCTOBER 2017

depart from Comfort Suites, near Texas State University
104 I-35 N, San Marcos, TX 78666s

8:00 - 17:00
Fieldtrip
(Lunch provided)

18:00 - 21:00
Icebreaker at AquaBrew
150 S. LBJ Dr, San Marcos, TX 78666

SATURDAY, 14 OCTOBER 2017

7:30 - 8:30
Registration
Coffee, fruit, and pastries
Evans Liberal Arts First Floor

8:30 - 8:45
Welcome and Opening Remarks
Dr. Alberto Giordano, Chair of Department of Geography
Dr. Mary Brennan, Dean of College of Liberal Arts
Evans Liberal Arts 114

Geomorphic Systems & Resilience

Evans Liberal Arts 114

8:45 - 9:15
Martin Thoms
U. New England, Australia
What do you mean, 'Resilient Geomorphic Systems'?

9:15 - 9:45
Hervé Piegay
Natl Ctr for Sci Research, France
Appraisal of Fluvial Corridor Futures: From Resilience to Persistence

9:45 - 10:15
Stephen Tooth
U. Aberyswyth, UK
The Geomorphology of Wetlands in Drylands: Resilience,Non-resilience, or ... ?

10:15 - 10:30
Break & Snacks

Extreme Events, Thresholds, & Resilience

Evans Liberal Arts 114

10:30 - 11:00
Jason Julian
Texas State U., USA
State-shifting at the Edge of Resilience: River Water Quality Responses to Changes in Land Use Intensity and Extreme Weather Events

11:00 - 11:30
Sarah Rathburn
Colorado State U., USA
Post-disturbance Sediment Recovery: Implications for Watershed Resilience

11:30 - 12:00
Emily Stanley
U. Wisconsin, USA
Anticipating Rapid Ecological Change in Lakes

12:00 - 13:30
Texas BBQ Lunch
Flowers Hall 230

Poster viewing
Evans Liberal Arts Atrium and First Floor

Eco-Geo Connections & Resilience

Evans Liberal Arts 114

13:30 - 14:00
Dov Corenblit
U. Clermont Auvergne, France
Niche Construction within Riparian Corridors: The Unexplored Role of Intra-specific Positive Interactions in Riparian Trees

14:00 - 14:30
Carla Atkinson
U. Alabama, USA
Including Ecogeomorphic Feedbacks for Enhancement of Ecological Function and Resiliency in Streams

14:30 - 15:00
Catalina Segura
Oregon State U., USA
Sediment Transport Influence on Primary Production in Rainfall Dominated Systems

15:00 - 15:15
Break & Snacks

Zoogeomorphology & Resilience

Evans Liberal Arts 114

15:15 - 15:45
David Butler
Texas State U., USA
Zoogeomorphology and Resilience Theory

15:45 - 16:15
Alex Fremier
Washington State U., USA
Sex that Moves Mountains: The Influence of Spawning Fish on River Profiles over Geologic Timescales

16:15 - 16:45
Invited Poster Introductions

Evans Liberal Arts 114

16:45 - 18:00
Poster Session

Evans Liberal Arts Atrium and First Floor

18:00 - 18:30
Walk (with campus tour) or Van to Banquet

18:30 - 21:00
Banquet, with after-dinner talk

City Park Rec Hall
170 Charles Austin Drive, San Marcos, TX 78666

David Montgomery
U. Washington, USA
Soil — The Key to Resilient Civilizations

SUNDAY, 15 OCTOBER 2017

7:30 - 8:30
Coffee, fruit, and pastries
Evans Liberal Arts First Floor

Coastal Geomorphology & Resilience
Evans Liberal Arts 114

8:30 - 9:00
Jonathan Phillips
U. Kentucky, USA
Coastal Wetlands, Sea-level, and the Dimensions of Geomorphic Resilience

9:00 - 9:30
Tim & Sheryl Beach
U.Texas, USA
Stability and Instability on Maya Lowlands Tropical Hillslope Soils

9:30 - 10:00
Zachary Tessler
CUNY, USA
Geomorphic, Anthropogenic, and Social Dimensions of Risk in Global River Deltas

10:00 - 10:15
Break & Snacks

Social-Ecological Systems & Resilience
Evans Liberal Arts 114

10:15 - 10:45
Brian Chaffin
U. Montana, USA
Social-Ecological Resilience and Geomorphic Systems

10:45 - 11:15
Meredith Steele
Virginia Tech U., USA
Land Use and Surface Water: The Reorganization of US Hydrography

11:15 - 11:45
Melissa Parsons
U. New England, Australia
From Academic to Applied: Operationalising Resilience in River Systems

11:45 - 13:00
Lunch and Discussion of synthesis paper
Flowers Hall 230

invited posters

Augustine Avwunudiogba
Cal State U.-Stanislaus
The Response of Erosion to Land Use Pattern in a Swidden Agroecosystem in a Humid Tropical Mountainous region of Eastern Mexico

Thomas Ballinger
Texas State U.
Variations in North Atlantic Sea Ice since the 1850s

Jacob Bendix
Syracuse U.
Feedbacks, Timing, and Biogeomorphic Response to Riparian Disturbance

Katie Costigan
U of Louisiana-Lafayette
Resistance and Resiliency of Intermittent Rivers

Judy Haschenburger
UT San Antonio
An Evaluation of Streambed Response

Edgardo Latrubesse
U. Texas
Large Alluvial Rivers, Vegetation, and Past-present Landscape Biogeomorphic Imprints

Kimberly Meitzen
Texas State U.
Catastrophic Flood Disturbance and a Community's Response to Plant Resilience in the Heart of the Texas Hill Country

Carlos Ramos-Scharron
U. Texas
Application of Hydro-Geomorphic Principles to the Management of Terrestrial Sediment Loading Rates into Coral-Bearing Waters

Benjamin Schwartz
Texas State U.
In-cave Hydrology in VA and TX and Differences in Vadose Storage Properties: Differences in Baseflow and Hydraulic Resilience of Small Tributaries after Drought

posters

Geospatial analysis of bank erosion for conservation planning, Lamar Lake Watershed, MO
Adams, Hannah R., Marc Owen, Robert T. Pavlowsky

Hydro-morphological characterization of landslide scar sites on Mt. Elgon, Eastern Uganda
Bamutaze, Yazidhi, Bob Nakileza, Geofrey Gabiri

Hydrology, soils, and their geomorphic record in the Okavango Delta, Botswana
Bean, Robert A., Timothy Beach, Kelley A. Crews, Thoralf Meyer

Recreational resilience of the upper San Marcos River, Texas, USA
Bosarge, Jeanett H., Jason P. Julian

Catastrophic flood influence on large woody debris size and distribution in a Missouri Ozarks river
Bournival, Leah, Kelly Rose, Joseph Nash, Josh Hess, Sarah LeTarte, Hannah Adams, Robert T. Pavlowsky

Hydrodynamic modeling of hydrologic surface connectivity within a coastal river-floodplain system
Castillo, Cesar R.

Ethnofluvial geomorphology: perception and the potential for resilience
Crews, Kelley A., Amelia C. Sosnowski

LiDAR-Based geomorphology of the Belize-Guatemala transboundary area: Legacies of anthropogenic and climate changes in a fluviokarst system
Donn, Leila, Timothy Beach, Sheryl Luzzadder-Beach, Jason Yaeger

Streamflow variability within four rivers in the eastern highland rim region of Tennessee
Dorn, Taylor, Katie H. Costigan, Joshuah S. Perkin

Quantifying ancient Maya impacts on the geomorphology of tropical wetlands using airborne LiDAR
Doyle, Colin, Samantha Krause, Timothy Beach, Sheryl Luzzadder-Beach

posters (continued)

Interactions between cohune palm (Attalea cohune) monodominant forests and soils
Eshleman, Sara, Timothy Beach

A web-based GIS utility for multi geomorphic hazards mapping and visualization- case study: Kan Basin, Tehran City, Iran
Gharehchahii, Saeideh, Matt Washburn, Kevin Schilly

Using resilience theory to study the hydrogeological character of the Upper Camp Bird III Rock Glacier, San Juan Mountains, Colorado
Granados-Aguilar, Raquel, John R. Giardino, Kaytan Kelkar

Win-win? The tradeoffs of floodplain reconnection along the Illinois River
Guida, Ross, Jonathan Remo

Geomorphic controls on riparian forest response to a catastrophic flood in Mark Twain National Forest, Missouri
Hess, Josh, Joseph Nash, Kelly Rose, Sarah LeTarte, Hannah Adams, Robert T. Pavlowsky

The impacts of Tropical Storm Cindy on a study site at McFaddin National Wildlife Refuge, Texas
Hodge, Joshua

The geomorphic origin and evolution of Grand Valley, western Colorado: a New investigation
Jeon, Kyungho, John R. Giardino

A review of biotic roles in disturbance induced regime shifts of geomorphic systems
Jerin, Tasnuba, Alice V. Turkington, Jonathan D. Phillips

Using a resilience approach for susceptibility to mass movement in the western San Juan mountains, CO
Kelkar, Kaytan, John R. Giardino

Resilience of channel sediment quality in mining-contaminated streams, Galena River Watershed, WI-IL
King, Dylan A., Robert T. Pavlowsky

posters (continued)

Freshwater mussels as ecogeomorphic agents: Literature synthesis and development of an in-stream experiment
Koerner, Matt

Paleoecology, genesis, and human manipulation of wetlands inNorthwestern Belize
Krause, Samantha M., Timothy Beach, Sheryl Luzzadder-Beach, Fred Valdez, Colin Doyle, Sara Eshleman, Leila Donn

Geomorphic effects of an extreme flood in a karst mountain watershed, southwest coast, Jamaica
LeTarte, Sarah, Matthew Connolly, Robert T. Pavlowsky

Ecosystem services and damage costs of federal lands: Case study of Gila National Forest, USA
Manning, Aspen, Jason P. Julian

The geomorphic nature of mountain bike impacts on selected trails near Austin, Texas
Martin, Ross

Modelling the support factor (P) as a function of socio-economic factors for improved erosion prediction in the Lake Victoria Basin of Uganda
Nadhomi, Daniel Luliro, Benard Oyo, George Jackson Majaliwa-Mwanjalolo, John Stephen Tenywa, Paul Musali

Geomorphic response to a catastrophic flood event, North Fork of the White River, Missouri Ozarks
Nash, Joe, Marc Owen, Robert T. Pavlowsky

Eco-geomorphic feedbacks stimulated by benthic macrofauna in streams: A review and current research with burrowing bivalves
Nickerson, Zachary L., Carla L. Atkinson

Gorillas as earth-movers: Identifying zoogeomorphic hotspots in Equatorial Africa
Pinon, Andrea E.

posters (continued)

Modeling debris cascades in the San Juan Mountains, Colorado: A preliminary graph theory approach
Qu, Tianyue, John R. Giardino, Kaytan Kelkar, Raquel Granados-Aguilar

Channel stability and sediment budget analysis of a human modified channel system in the Missouri Ozarks
Reminga, Katy, Matthew Thies, Rachael Bradley, Marc Owen, Robert T. Pavlowsky

Hydrologic effects of prescribed burning in Mark Twain National Forest, Missouri
Roman, Grace, Megan Hente, Joe Nash, Marc Owen, Robert T. Pavlowsky

Influence of neighborhood history on metal concentrations in roadside soils and street dusts, Springfield, Missouri
Rose, Kelly, Robert T. Pavlowsky

Impact of spring-associated riparian vegetation on channel morphology and sediment distribution in ephemeral dryland channels: Henry Mountains, Utah, USA
Southard, Paul, Joel Johnson, Daniella Rempe, Ashley Matheny

Paleoflood investigations and physiographic characteristics associated with susceptibility to flooding in the mountainous Colorado Front Range
Trivino, Natalie, Michael Daniels

Geomorphologic impacts and timeline reconstruction of Holocene Jökulhlaups along the Hvítá River and Gullfoss, Iceland
Wells, Greta

Seventy-five years after contour terracing on the Wasatch Plateau of Central Utah
Whitesides, Clayton J.

invited paper abstracts

Including ecogeomorphic feedbacks for enhancement of ecological function and resiliency in streams

Atkinson, Carla L.

University of Alabama, Department of Biological Sciences

River form and function depends on the interactions between the living and nonliving world, but a dominant paradigm underlying ecogeomorphic work consists of a top-down, unidirectional approach with abiotic forces driving biotic systems. This traditional hierarchal framework is inadequate in communicating how biological systems may lead to changes in channel morphology, sediment cycling, and system-scale functions. Yet, substantial evidence that organisms influence fluvial geomorphology exists, specifically the ability of aquatic vegetation and lotic animals to modify flow velocities and sediment deposition and transport. Furthermore, vital ecosystem processes such as biogeochemical nutrient cycling represent the exchanges that are occurring between geomorphological and biological systems. Conceptual frameworks should acknowledge that hydrologic, geomorphologic, and ecologic processes operate on different temporal scales, generating bidirectional feedback loops over space and time. I will review selected case studies highlighting the role organisms play in moderating geomorphic processes and how these interactions influence essential ecosystem process such as biogeochemical nutrient recycling. I will also discuss how biophysical interactions can provide information essential to improving predictions of system-scale river functions, specifically sediment transport and biogeochemical cycling, and discuss tools I am implementing to study these interactions. Hydro- and geomorphologic processes, operating episodically during bankfull conditions, influence ecological processes (e.g., biogeochemical cycling) occurring over longer time periods during base-flow conditions. These feedbacks enhance the resiliency of fluvial landforms and ecosystem processes, allowing physical and biological processes to pull and push against each other over time.

Stability and instability on Maya lowlands tropical hillslope soils

Beach, Timothy[1], Sheryl Luzzadder-Beach[1], Duncan Cook[2], Samantha Krause[1], Colin Doyle[1], Sara Eshleman[1], GretaWells[1], Nicholas Dunning[3], Michael L. Brennan[4], Nicholas Brokaw[5], Marisol Cortes-Rincon[6], Gail Hammond[7], Richard Terry[8], Debora Trein[1], Sheila Ward[9]

[1]University of Texas at Austin, [2]Australian Catholic University (Australia), [3]University of Cincinnati, [4]Brennan Exploration, [5]University of Puerto Rico-Río Piedras, [6]Humboldt State University, [7]University College London (United Kingdom), [8]Brigham Young University, [9]Mahogany for the Future, Inc.

Lake Core evidence links accelerated soil erosion with ancient Maya history, 3000 to 1000 years ago. With seven new catenas and synthesized evidence, we followed the sediment cascade up

tropical forest catenas. Four footslopes or depressions in areas of high ancient occupation preserved evidence of clay-textured paleosols buried by coarse, ancient Maya period sediments. Three footslopes had little deposition, and these came from areas of scant ancient occupation. We used major elemental concentrations across the catenas to estimate relative ages and contributions of autochthonous and allochthonous materials. Very low ratios (Ca + Mg) / (Al + Fe + Mn) occurred in older, buried soils in footslopes and on little-eroded slopes. High ratios occurred in soils possibly formed since Maya abandonment. Carbon isotopes (δ13C) also provide evidence of vegetation change. We found evidence for maize or other alien C4 species in an ancient terrace soil and in buried footslopes but only evidence for C3 species (like tropical trees) on steep backslopes. Since steep slopes preserved no evidence of C4 species, perhaps indicating ancient Maya forests reserves. Alternatively, the ancient Maya eroded slopes, and the C3 species signatures reflect soil developed under forest for a millennium. Three lines of evidence suggest these steep soils are young: elevated (Ca + Mg) / (Al + Fe + Mn) values, skeletal soil profiles, and low soil magnetic susceptibility. The anthropogenically eroded, buried, and terraced slopes influenced modern tree distributions, because many tree species have strong preferences for ancient Maya altered soil types and topographic situations.

Zoogeomorphology and resilience theory

Butler, David R., Faisal Anzah, Paepin D. Goff, Jennifer Villa

Texas State University, Department of Geography

Zoogeomorphology, the study of animals as geomorphic agents, has been largely overlooked in the context of resilience theory and biogeomorphic systems. In this paper, examples are provided of the interactions between external landscape disturbances and zoogeomorphological agents. We describe cases in which naturally occurring zoogeomorphological agents occupy a landscape and examine whether those zoogeomorphic agents provide resilience to a landscape or instead serve as a landscape stress capable of inducing a phase-state shift. Several cases are described whereby the presence of exotic (introduced) zoogeomorphic agents overwhelm a landscape and induce collapse. The impact of climate change on species with zoogeomorphological importance is discussed in the context of resilience of a landscape. We conclude with a summary diagram illustrating the relationships existing between zoogeomorphic impacts and landscape resilience in the context of our case studies and speculate about the future of the study of zoogeomorphology in the framework of resilience theory.

Social-ecological resilience and geomorphic systems

Chaffin, Brian C.[1], Murray Scown[2]

[1]University of Montana, W.A. Franke College of Forestry & Conservation, [2]Lund University (Sweden), Center for Sustainability Studies (LUCSUS)

Governance of coupled social-ecological systems (SESs) and the underlying geomorphic processes that structure and alter the Earth's surface is a key challenge for global sustainability in the increasing uncertainty and change that defines the

Anthropocene. Social-ecological resilience as a concept of scientific inquiry has contributed to new understandings of the dynamics of SESs, increasing our ability to contextualize and implement governance in these systems. Often, however, the importance of geomorphic change and geomorphological knowledge is somewhat missing from processes employed to inform SES governance. In this contribution, we argue that geomorphology and social-ecological resilience research should be integrated to improve governance towards sustainability. We first provide definitions of engineering, ecological, community, and social-ecological resilience, and then explore the use of these concepts within and alongside geomorphology in the literature. While ecological studies often consider geomorphology as an important factor influencing the resilience of ecosystems, and geomorphological studies often consider the engineering resilience of geomorphic systems of interest, very few studies define and employ a social-ecological resilience framing and explicitly link the concept to geomorphic systems. We present five key concepts—scale, feedbacks, state or regime, thresholds and regime shifts, and humans as part of the system—which we believe can help explicitly link important aspects of social-ecological resilience inquiry and geomorphological inquiry in order to strengthen the impact of both lines of research. Finally, we discuss how these five concepts might be used to integrate social-ecological resilience and geomorphology to better understand change in, and inform governance of, SESs.

Niche construction within riparian corridors: The unexplored role of intra-specific positive interactions in riparian trees

Corenblit, Dov
Université Clermont Auvergne (France)

Within rivers, pioneer riparian trees leads to the construction of wooded fluvial landforms. Grouped individuals are less prone to be uprooted than free-standing individuals. Riparian trees which grow in dense stands also enhance the trapping of sediment, organic matter and nutrients. The wooded biogeomorphic landforms which result from the effect of vegetation on geomorphology lead to a positive niche construction. The nature and intensity of biotic interactions between trees of the same species which form dense stands and construct together their niche remain unclear. We suspect that direct intra-specific interactions, such as cooperation and altruism, operate during the niche construction process. We propose a theoretical framework of intra-specific positive interactions between riparian trees. Trees that grow within dense stands improve their fitness because individuals protect each other from shear stress. In addition to the improved capacity to trap mineral and organic matter, individuals which constitute the dense stand can cooperate to mutually support a mycorrhizal fungi network that will improve growth and survival. Functional natural root grafting between neighbour trees could also represent an advantage for anchorage and nutrient uptake and exchange potentially linked to an altruistic behaviour.

Sex that moves mountains: The influence of spawning fish on river profiles over geologic timescales

Fremier, Alexander K.[1], Brian Yanites[2], Elowyn M. Yager[3]

[1]*Washington State University, School of the Environment,* [2]*Indiana University, Earth and Atmospheric Sciences,* [3]*University of Idaho, Department of Civil Engineering, Center for Ecohydraulics Research*

A key component of ecological resilience is to understand feedbacks among components of biophysical systems. While physically-based explanations of biological speciation are common, less common is the inverse process examined; can a speciation event have significant influence on physical processes and patterns in a landscape? When such processes are considered, many studies focus on the short-term physical and biological effects, rather than long-term impacts. Here, we formalized the physical influence of salmon spawning on stream beds into a model of channel profile evolution by altering the critical shear stress required to move stream bed particles. We then asked, if spawning and an adaptive radiation event (similar to Pacific salmon) could have an effect on channel erosion processes and stream profiles over geological time scales. We found that spawning can profoundly influence the longitudinal profiles of stream beds and thereby the evolution of entire watersheds. The radiation of five Pacific salmon from a common ancestor, additionally, could also cause significant geomorphic change by altering a wider section of the profile for a given distribution of grain sizes. This modeling study suggests that biological evolution can impact landscape evolution by increasing the sediment transport and erosion efficiency of mountain streams. Moreover, the physical effects of a species on its environment might be a complementary explanation for rapid adaptive radiation events in species, through the creation of new habitat types. This example provides an illustrative case for thinking about the long- and short-term coupling of biotic and abiotic systems.

State-shifting at the edge of resilience: River water quality responses to changes in land use intensity and extreme weather events

Julian, Jason P.[1]*, Samantha Abbott*[1]*, Ioannis Kamarinas*[1]*, Kimberly M. Meitzen*[1]*, Braden Owsley*[2]*, Kirsten de Beurs*[2]

[1]*Texas State University, Department of Geography*

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The interaction of climate, geomorphology, and land use dictates river water quality. Accordingly, the resilience of catchments to disturbances can be assessed with spatiotemporal patterns of river water quality. In this synthesis of multiple case studies across New Zealand, we examine thresholds of resilience by comparing river water quality responses to disturbances from land use and extreme weather events. One case study, in the hill country of the lower North Island, was a decade-long examination of the short- and long-term effects of an extreme storm event on sediment supply and exhaustion in two catchments that have experienced intense land use changes and frequent broad-scale landslides. In a different catchment, in the upper North Island, we compared weekly time-series of land disturbance and water quality variables (suspended sediment, turbidity, visual clarity) for the 2000–2013 period, which

included the drought of record. Finally, we interpreted monthly water quality state and trends for the 26 years from 1989 to 2014 in the National Rivers Water Quality Network (NRWQN) – consisting of 77 sites on 35 mostly large river systems. To characterize land use intensity, we analyzed spatial and temporal changes in livestock density and land disturbance at the catchment scale, as well as fertilizer inputs at the national scale. From all these studies, we found that many catchments are at the edge of resilience, where water quality can shift between states depending on the interaction of climate, land use, and geomorphology.

Soil — the key to resilient civilizations

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Soil erosion helped shape history as society after society used up a natural endowment of fertile soil, leaving a legacy of impoverished lands. Combining the history of land use with recent data shows that soil erosion under conventional agriculture greatly exceeds rates of soil production and geological erosion rates. Modern society thus faces a fundamental challenge in feeding a growing population. Global soil degradation presents a fundamental societal challenge in which the slow pace of environmental change makes solutions difficult to adopt. Yet farmers around the world working are working on soil health building practices that could bring humanity's ailing soil back to life remarkably fast based on the principles of conservation agriculture to rebuild degraded soil fertility. Visits to farms in the industrialized and developing worlds showed that the combination of no-till planting, cover crops, and diverse crop rotations can provide a profitable recipe to rebuild soil organic matter in a wide variety of settings. Farmers using these unconventional practices cultivate beneficial soil life, smother weeds, and suppress pests while relying on far less, if any, fertilizer and pesticides. Using less fossil fuel and agrochemicals while maintaining crop yields helps farmers with their bottom line. These regenerative practices translate into farms that use less water, generate less pollution, lower carbon emissions—and stash an impressive amount of carbon underground.

From academic to applied: Operationalising resilience in river systems

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The concept of resilience acknowledges the ability of societies to live and develop with dynamic environments. Given the recognition of the need to prepare for anticipated and unanticipated shocks, applications of resilience are increasing as the guiding principle of public policy and programs in areas such as disaster management, urban planning, natural resource management, and climate change adaptation. River science is an area in which the adoption of resilience is increasing, leading to the proposition that resilience may become a guiding principle of river policy and programs. Debate about the role of resilience in rivers is part of the scientific method, but disciplinary disunity about the ways to approach resilience application in policy and programs may leave river science out of the policy process. We propose six elements that need to be considered in the design and

implementation of resilience-based river policy and programs: rivers as social-ecological systems; the science-policy interface; principles, capacities, and characteristics of resilience; cogeneration of knowledge; adaptive management; and the state of the science of resilience.

Coastal wetlands, sea level, and the dimensions of geomorphic resilience

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Geomorphic system resilience is often perceived as an intrinsic property of system structure and interactions but is also related to idiosyncratic place and history factors. The importance of geographical and historical circumstances makes it difficult to generate categorical statements about geomorphic resilience. However, network-based analyses of system structure can be used to determine the dynamical stability (= resilience) based on generally applicable relationships and to determine scenarios of stability or instability. These provide guidelines for assessing place and history factors to assess resilience. A model of coastal wetlands is analyzed, based on interactions among relative sea level, wetland surface elevation, hydroperiod, vegetation, and sedimentation. The system is generally (but not always) dynamically unstable and non-resilient. Because of gradients of environmental factors and patchy distributions of microtopography and vegetation, a coastal wetland landscape may have extensive local variations in stability/resilience and in the key relationships that trigger instabilities. This is illustrated by a case study where dynamically unstable fragmentation is found in two nearby coastal wetlands in North Carolina's Neuse River estuary—Otter Creek Mouth and Anderson Creek. Neither is keeping pace with relative sea level rise, and both show unstable state transitions within the wetland system; but locally stable relationships exist within the wetland systems.

Appraisal of fluvial corridor futures: From resilience to persistence

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What is a resilient river? From a geomorphic point of view, the answer is complex because resilience is a polysemic term and its use is variable from one discipline to another. In all cases, it is a way of thinking river future in term of persistence, sometimes cyclically, sometimes in a trajectorial perspective. Its popularity in ecology and the socio-ecological systems community, following the pioneer works of Holling (1973), has influenced the way we are considering it in geomorphology and creates misunderstanding and debate. In this contribution, we introduce the different resiliences, showing the evolution of the term through time and its implicit presence in the (fluvial) system theory. We then explore some challenging issues in geomorphology related to resilience when considering river responses to flood events and to an external set of drivers.

invited paper abstracts

Post-disturbance sediment recovery: Implications for watershed resilience

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Sediment recovery following disturbances is a measure of the time required to attain pre-disturbance sediment fluxes. Insight into the controls on recovery processes builds understanding of geomorphic resilience. We assess post-disturbance sediment recovery in three small (1.5-100 km^2), largely unaltered watersheds within the northern Colorado Rocky Mountains affected by wildfire, floods, and debris flows. For all case studies, event sediment recovery followed a nonlinear pattern: initial high sediment flux followed by decreasing sediment fluxes over time. Disturbance interactions are evaluated after a high-severity fire within the South Fork Cache la Poudre watershed was followed by an extreme flood one year post-fire, producing a compound disturbance that hastened suspended sediment recovery to pre-fire concentrations. Wildfires over the last 1900 YBP in the South Fork watershed indicate fire recurrence intervals of ~600 years. Debris flows within the upper Colorado River basin over the last two centuries have shifted the baseline of sediment recovery caused by anthropogenic activities. A >200 year flood on North St. Vrain Creek with an impounding reservoir resulted in extreme sedimentation that led to a physical state change. An index of resilience as sediment recovery/disturbance recurrence interval provides a relative comparison between sites. Sediment recovery and channel form resilience may be inversely related because of high or low physical complexity. Management guidelines to enhance geomorphic resilience by promoting natural processes that maintain physical complexity are presented. Sediment connectivity within watersheds is an additional factor to consider when establishing restoration treatment priorities.

Sediment transport influence on primary production in rainfall dominated systems

Segura, Catalina
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This study explores how spatial and temporal variability of stream flow and sediment transport influences the biomass of benthic algae in mountain stream. We characterized spatial variability in sediment transport for 9 flow events (0.1-1.7 of bankfull flow), coupling high resolution (<0.1 m^2) two-dimensional shear stress values with detailed measurements of the channel substrate. The stream bed was categorized into regions of high and low disturbance based on potential mobility of the median grain size. High resolution (<0.25m^2) measurements of benthic Chlorophyll-*a* (Chl-*a*) were taken on 18 sampling dates before and after high flow events in regions of the streambed with contrasting disturbance. We found that the percentage of the channel likely to be disturbed varied greatly across modeled flows (7.7- 70.4. Over the 18 sampling dates Chl-*a* differed between the two disturbance level categories on 14 occasions. However, low disturbance locations were not always associated with higher Chl-*a*. Resistance of the algal communities to bed disturbance and resilience to recovery following a flow event varied spatially. Areas with low shear stress were less susceptible to scour during moderate disturbance events but were slower to recover when scour occurred. In contrast, high shear stress areas responded rapidly to flood events with rapid declines, but recovered more quickly and appeared to have high potential for maximum accrual. Ultimately, timing along with the inverse

relationship between resiliency and disturbance frequency highlights the complexity of these processes and the importance of studying these processes with high resolution across spatial and temporal scales.

Anticipating rapid ecological change in lakes

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Lakes have been valuable laboratories for development and testing resilience and regime shift theory. This utility reflects the occurrence of different phenomena amenable to studying resilience and regime shifts (e.g., abrupt shifts from vegetated to turbid phytoplankton states, food web destabilization, or fisheries collapse); the opportunity to conduct whole-ecosystem experiments to evaluate theory; and occurrence of multiple adjacent lakes that provide replicate study systems. Studies of resilience in lakes have consistently emphasized endogenous, biological mechanisms that maintain the ecosystem in a particular state rather than on external disturbances or geomorphic processes. This raises the question: what may have been missed by not incorporating geomorphology in lake studies? Opportunities to integrate geomorphic processes that shape lake basins are limited given that most lakes were formed by glacial action. Sediment transport may be an exception, particularly as this process also delivers phosphorus to lakes and thus often plays a role in the shift to a turbid eutrophic state. Yet because sediment mobilization and transport occurs beyond the edges of lakes, its integration into resilience thinking for lakes has been elusive. Perhaps the best opportunity for infusing lake resilience research with geomorphic understanding is to focus on geomorphic pattern rather than process. Examination of an ongoing decline in coolwater fisheries in many northern Wisconsin (USA) lakes has highlighted how basin morphology affects the expression of a slowly-changing driver (climate) and therefore provides a means of identifying lakes that are more or less resilient to changes in this and other regional drivers.

Land use and surface water: The reorganization of US hydrography

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Virginia Tech University

The surface waters of developed landscapes undergo a physical reorganization, yet the resulting hydrographic structure and how it differs across diverse landscapes remains poorly characterized and understood. This study examined how the abundance and impairment of surface water differs with population size and regional context by quantifying the stream length, water body area, and impaired stream length for 3520 cities in the United States with populations from 2500 to 18 million, using the National Hydrography Dataset and the EPA's 303(d) list. Results show that abundance of stream length and water body area in cities actually increases with city area; however, the per person abundance decreases with population size. Relative to population, impaired stream length did not increase until city populations were >25,000 people, then scaled linearly with population. Biophysical context and land cover explained some variation in abundance and impairment. Development intensity correlated with stream density and

impairment; however, those relationships depended on the orientation of the land covers. When high intensity development occupied the local elevation highs (+15 m) and undeveloped land the elevation lows, the percentage of impaired streams was less than the opposite land cover orientation (-15 m) or very flat land. These results show that city size and by biophysical setting interact with land cover intensity to influence surface water abundance and impairment across contiguous US cities.

Geomorphic, anthropogenic, and social dimensions of risk in global river deltas

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Modern deltas are dependent on human-mediated freshwater and sediment fluxes. Changes to these fluxes impact delta biogeophysical functioning, and affect the long-term sustainability of these landscapes for both human and natural systems. Here we present contemporary estimates of long-term mean sediment balance and relative sea-level rise across 46 global deltas. We model scenarios of contemporary and future water resource management schemes and hydropower infrastructure in upstream river basins to explore how changing sediment fluxes impact relative sea-level in coastal delta systems. Model results show that contemporary sediment fluxes, anthropogenic drivers of land subsidence, and sea-level rise result in relative sea-level rise rates in deltas that average 6.8 mm/year. Assessment of impacts of planned and under-construction dams on relative sea-level rise rates suggests increases on the order of 1 mm/year in deltas with new upstream construction. Sediment fluxes are estimated to reduce by up to 60% in the Danube and 21% in the Ganges-Brahmaputra-Megnha if all currently planned dams are constructed. Reduced sediment retention on deltas due to increased river channelization and management has a larger impact, increasing relative sea-level rise on average by nearly 2 mm/year. Long-term delta sustainability requires a more complete understanding of how geophysical and anthropogenic change impact delta geomorphology. Local and regional strategies for sustainable delta management that focus on local and regional drivers of change, especially groundwater and hydrocarbon extraction and upstream dam construction, can be highly impactful even in the context of global climate-induced sea-level rise.

What do you mean, 'resilient Geomorphic Systems'?

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Resilience thinking has many parallels in the study of geomorphology. There are similarities and intersections between the scientific discipline of geomorphology and the scientific concept of resilience. Many of the core themes fundamental to geomorphology are closely related to the key themes of resilience. Applications of resilience thinking in the study of natural and human systems have expanded, based on the fundamental premise that ecosystems, economies and societies must be managed as linked social-ecological systems. Despite geomorphology and resilience sharing core themes, there is

limited appreciation of the history and development of geomorphology as a field of scientific endeavor by many in the field of resilience, as well as a limited awareness of the foundations of the former in the more recent emergence of resilience. This potentially limits applications of resilience concepts to the study of geomorphology. In this manuscript we provide a collective examination of geomorphology and resilience as a means to conceptually advance both areas of study, as well as to further cement the relevance and importance of not only understanding the complexities of geomorphic systems in an emerging world of interdisciplinary challenges but also the importance of viewing humans as an intrinsic component of geomorphic systems rather than just an external driver. The application of the concepts of hierarchy and scale, fundamental tenets of the study of geomorphic systems, provide a means to overcome contemporary scale-limited approaches within resilience studies. Resilience offers a framework for geomorphology to extend its application into the broader social-ecological domain.

The geomorphology of wetlands in drylands: Resilience, non-resilience, or …?

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How resilient are wetlands to disturbances such as extreme weather events, longer climate change, and human activities? In geomorphology and cognate disciplines, resilience is variably defined, but commonly is taken to mean the ability of a system to: A) withstand disturbance; B) recover from disturbance; or C) adapt and evolve in response to disturbance to a more desirable (e.g. stable) configuration. Studies of wetland resilience tend to focus on permanently-saturated humid region wetlands but whether the findings can be readily transferred to wetlands in drylands remains unclear. Given the natural climatic variability and overall strong moisture deficit characteristic of drylands, are such wetlands likely to be more resilient or less resilient? Focusing on wetlands in the South African drylands, this presentation will use geomorphological, sedimentological and geochronological datasets to provide the spatial (up to 50 km^2) and temporal (late Quaternary) framework for an assessment of geomorphological resilience. Findings demonstrate that some wetlands have been highly resilient to environmental change but others have been non-resilient, with marked transformations in channel-floodplain structure and process connectivity having been driven by natural factors (e.g. local baselevel fall) or human activities (e.g. floodplain drainage). Key issues related to assessment of wetland resilience include channel-floodplain dynamics in relation to geomorphological thresholds, wetland geomorphological 'life cycles', and the relative roles of natural and human activities. Geomorphologists can help apply the resilience concept in wetland management but consideration needs to be given to how geomorphological resilience interfaces with other dimensions of resilience, especially ecological resilience and socioeconomic resilience.Including ecogeomorphic feedbacks for enhancement of ecological function and resiliency in streams.

Geospatial analysis of bank erosion for conservation planning, Lamar Lake Watershed, MO

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Eutrophication is caused by excess nutrients and sediment that produce large algal blooms. In municipal water supplies large amounts of algae lead to chronic taste and order problems often disrupting civilian use. Lamar Lake, located in SW Missouri, is experiencing this problem. In 1998 Lamar Lake was listed under section 303(d) of the federal Clean Water Act for algae pollutants caused by excess phosphorus. However, little is known about the role of bank erosion as a nonpoint pollution source in Lake Lamar. Historical aerial photos where used to digitize streams to analyze changes in channels for the following years: 1953, 1966, 1997, 2008, and 2016. Disturbances were classified using a conservative 4.1 meter buffer based on the 1997 aerial photos Max Point to Point Error. Riparian corridor condition was classified using the 2016 aerial imagery. The channel change and riparian classifications will be used to identify potential nonpoint sediment sources to the lake. Results will be used plan a field study of channel stability and bank erosion to help identify conservation practices that are most beneficial to improve water quality.

The response of erosion to land use pattern in a Swidden agroecosystem in a humid tropical mountainous region of Eastern Mexico

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The replacement of natural ecosystems with agroecosystems is a growing trend in many regions of the world. Land cover change associated with agriculture may change landscape sensitivity and resilience with ramifications for geomorphic systems response and recovery. Understanding how agroecosystems respond to geomorphic disturbances is vital to the management of unintended land degradation associated with agriculture. This study employs a space for time approach to investigate the response of soil erosion to land use pattern in a swidden cultivation gradient. Bounded runoff plots were installed on plots which have been under cultivation for 1, 2, 3, and 4 years and under fallow for 1, 5 and 15 years to monitor soil erosion over two wet seasons. Soil erosion was monitored on runoff plot on a natural forest for the same period. Rainfall events were monitored while soil properties were determined in the field and from soil samples analyzed in the laboratory. Results show that compared to the forest plot erosion was 94.4% in cultivated plots and 68.2% in fallow plots. The rate of erosion varied according to the age of cultivation and fallow with the highest rate occurring on plots under cultivation for 3 years. Over the cultivation age gradient, erosion increased during the second year, peaked during the third, and declined during the fourth year of cultivation. The study suggests that under certain edaphic conditions, spatial heterogeneity of land use pattern in a swidden agroecosystems may help improve resilience and recovery and reduce the rate of erosion.

Variations in North Atlantic sea ice and climate since the 1850s

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The North Atlantic Arctic (NAA) region is a dynamic, yet complex environment where cryospheric changes involving snow cover, glaciers, and sea ice are often non-linearly connected to ocean-atmosphere conditions locally and/or across lower latitudes. This is particularly evident in Baffin Bay waters, as earlier spring sea ice melt onset (since the late 1970s) and subsequent, patchy melt along western portions of the Greenland ice sheet have been associated with increased incidence of high pressure anomalies over the region amidst background Arctic amplification of air temperatures. In this study, we analyze recently-released, monthly sea ice concentration and climate records spanning the 1850s to present focused on the Baffin Bay region. Using descriptive statistics and trend analyses we look to assess variability and change characteristics of the sea ice cover time series, including analyses of climatological sub-periods within the ~160-year record. Subsequently, we employ a composite approach to begin to identify some ocean-atmosphere patterns in the 500 hPa geopotential height, sea-level pressure, and sea surface temperature fields associated with extremely high and low monthly sea ice conditions. The analyses aim to shed light on the complex physical drivers of low frequency ice cover changes and inform understanding of recent abrupt climate change across the NAA.

Hydro-morphological characterization of landslide scar sites on Mt. Elgon, Eastern Uganda

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Whilst disastrous landslide hazards are prevalent on the transboundary Mt. Elgon system and are expected to increase owing to the demographic and climatic changes, limited attention has been given to the hydrologic and morphological factors underpinning land slide occurrence. Yet landslide hazards in this region have implications on ecosystem and livelihood resilience. The thrust of this ongoing study is to characterize the hydrological and morphological dynamics at the sites that have experienced landslide hazards. An inventory of landslide scars was undertaken and sites geo-referenced using a high resolution GPS receiver. In total 110 landslides were recorded. For hydrological dynamics, we determined the infiltration rates at selected sites landslide scar sites using double ring infiltrometers. In total, we ran 31 infiltration tests (at altitudes between 1332 and 1461 meters above sea level) covering the lower, middle and upper segments of each selected site with three replications. Preliminary results show that infiltration rates are highly variable within and across landslide scar sites (559+287 mm/yr; CV=51%). Steady state infiltration rates varied from 204 to 1320 mm/yr across the sites. A hillslope scale investigation revealed proximity of landslide scars to linear features especially footpaths and ridges, which alter hydrological dynamics resulting in slope failures. Morphologically, landslide scars are largely concentrated on convex slopes with gradient >30%.

Hydrology, soils, and their geomorphic record in the Okavango Delta, Botswana

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Flooding patterns of the MOZ (Makgadikgadi-Okavango-Zambezi Basin) of northern Botswana are not only a local concern but moreover of global interest, underscored by the Delta's status as one of under 70 wetlands globally that have both Ramsar and UNESCO World Heritage status. In the past, these three areas connected to form a megalake, Lake Makgadikgadi, several times larger than the U.S. Great Lakes today and residing along borders of the Okavango Delta, which terminates in the Mababe Depression, the Makgadikgadi Pans, or Lake Ngami. Despite consensus that a giant lake existed, disagreements remain on when and how it was filled. Examination of the present state of the delta's edge and how the delta moved in the past are critical. MOZ edges are sensitive to climate and therefore can be used to assess climatic variability in ways not previously explored or – more importantly – not possible to examine in other locations and further complicated by precipitation varying up to 80-90% annually. Extensive studies of deltaic change processes exist, the edges of the MOZ are less studied. This paper focuses on a catena of soils representing typical geomorphic surfaces found in MOZ's distal portions. Soil profiles reveal past flooding frequency and extent in lacustrine deposits. Combined with carbon dating of organics and stable isotope analysis of carbon for both humin and bulk organic matter, together these allow for an improved and novel understanding of dynamics at a finer spatial and temporal scale by leveraging intensive fieldwork and a uniquely positioned megafan system.

Feedbacks, timing, and biogeomorphic response to riparian disturbance

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Studies of biogeomorphic response to disturbance have typically focused on the impacts of individual events. However, those impacts are often dependent on antecedent conditions that reflect prior disturbance history. A (reasonably) straightforward example is the feedback between floods and the contribution of vegetation to hydraulic roughness. A densely vegetated streambank is likely to have high Manning's n values, moderating the geomorphic and ecological impacts of small and moderate floods. But in the aftermath of an extreme flood that removes the vegetation, roughness is reduced, and the impacts of subsequent small and moderate floods will be greater than they otherwise would have been. Prediction of disturbance impacts therefore requires consideration of the details of both the disturbance history of a site and of its geomorphic (substrate characteristics, etc.) and ecological (species composition, etc.) characteristics. This poster presents an approach to predicting the likely trajectories of disturbance and recovery in southern California riparian systems, based on the type, magnitude and, history and timing of disturbance, as well as site characteristics. This conceptual approach emphasizes the non-random but historically contingent nature of biogeomorphic interactions.

Recreational resilience of the upper San Marcos River, Texas, USA

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As population and tourism continue to flourish in the City of San Marcos, so too will the need to effectively balance the management of ecosystem services. The objective of this study is to reveal spatiotemporal patterns in recreation along the San Marcos River (SMR) within the context of carrying capacity. Recreational services available along the SMR are of immense value to the city and provide benefits to a wide-range of users. The study area for this project is comprised of six parks located along the SMR and within city limits. Using an Unmanned Aerial Vehicle (UAV), photos covering the entire study area were taken between Memorial and Labor Day holidays with each day consisting of morning, midday, and afternoon observations. These photos were processed to produce high-resolution orthomosaic images, and subsequently analyzed to quantify recreational usage by detecting the number of people present across space and time. Patterns of usage were then compared to river features to assess potential impacts of usage on the river. High-resolution spatio-temporal data like these have the potential to inform adaptive natural management.

Catastrophic Flood Influence on Large Woody Debris Size and Distribution in a Missouri Ozarks River

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Hydrological studies in the Midwest United States indicate an emerging trend of increasing magnitude and frequency of river flooding across the region. However, the effects of a more active flood regime on fluvial wood recruitment, transport, and geomorphic impacts are not well understood. Therefore, the purpose of this study is to compare the spatial patterns and characteristics of fluvial wood in the North Fork of the White River in the Missouri Ozarks before and after a “1000-year” flood event which occurred in April-May 2017. The study reach is 1 km long with wetted channel widths ranging from 30-50 m and bar/bench widths from 30-70 m, where they occur. All pieces >0.1 m diameter and >1.5 m in length were located by GPS and characterized according to orientation, size, condition, and geomorphic effect. Results will describe patterns of fluvial wood orientation/spacing, size, condition, and influence on channel form and sediment. Measured wood volumes will be compared to pre-flood conditions and other regions. This study presents preliminary results of a NSF-RAPID project to monitor the impacts and recovery of Ozark river systems to floods.

Hydrodynamic modeling of hydrologic surface connectivity within a coastal river-floodplain system

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Hydrologic surface connectivity (HSC) within river-floodplain environments is a useful indicator of the overall health of riparian habitats because it allows connections amongst components/landforms of the riverine landscape system to be quantified. Overbank flows have traditionally been the focus for analyses concerned with river-floodplain connectivity, but recent works have identified the large significance from sub-bankfull streamflows. Through the use of morphometric analysis and a digital elevation model that is relative to the river water surface, we previously determined that >50% of the floodplain for Mission River on the Coastal Bend of Texas becomes connected to the river at streamflows well-below bankfull conditions. Guided by streamflow records, field-based inundation data, and morphometric analysis; we develop a two-dimensional hydrodynamic model for lower portions of Mission River Floodplain system. This model not only allows us to analyze connections induced by surface water inundation, but also other aspects of the hydrologic connectivity concept such as exchanges of sediment and energy between the river and its floodplain. We also aggregate hydrodynamic model outputs to an object/landform level in order to analyze HSC and associated attributes using measures from graph/network theory. Combining physically-based hydrodynamic models with object-based and graph theoretical analyses allow river-floodplain connectivity to be quantified in a consistent manner with measures/indicators commonly used in landscape analysis. Analyzes similar to ours build towards the establishment of a formal framework for analyzing river-floodplain interaction that will ultimately serve to inform the management of riverine/floodplain environments.

Resistance and resiliency of intermittent rivers

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Intermittent rivers oscillate between aquatic and terrestrial states as a result of the dynamic connectivity and temporal continuity of surface waters. Inadequate management, practices, and protective policies and legislation have resulted in intermittent rivers remaining particularly endangered ecosystems. In recent years, there has been a significant increase in research by both earth scientists and biologists on intermittent rivers. We cannot properly evaluate ecological responses or inform management and protective policies without a baseline understanding of the patterns in which intermittent rivers dry down and wet up. Patterns of surface flow in intermittent can vary substantially within and between watersheds where is has been demonstrated that immediately adjacent watersheds have very different patterns of surface flow. Spatiotemporal dynamics of network expansion and contraction cycles are complex. Two commonly used methods to determine spatiotemporal patterns of surface water in intermittent rivers are electrical resistivity (ER) sensors and wet/dry mapping. The advantages and disadvantages of each technique are explored for a variety of hydroclimatic regimes- from the desert southwest to the humid subtropics. The use of ER sensors for intermittent research has also increased recently, but, to date, there is no known comparison of the results of ER sensor data and wet/dry mapping data. The results of this work begin to understand the different patterns of surface water in intermittent rivers and will help advise and assess current methods used to characterize them.

Ethnofluvial Geomorphology: Perception and the potential for resilience

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Water literally shapes the world's terrestrial landscapes; and through the predictability of fluvial processes or lack thereof, also shapes the environmental perception, livelihood portfolio, and landscape impacts of residents within the impact zone of those hydrological processes. This work uses a socio-ecological systems (SES) approach, refining it explicitly to focus on communities and their interactions with fluvial geomorphic processes across three continents and thirteen study sites, including the Okavango Delta, Botswana and the Peruvian Amazon. Household interviews on environmental perceptions of flooding and precipitation change were leveraged against satellite time series data to better understand people's adaptions through mechanisms such as livelihood portfolio changes, migration, and landscape modification. Of particular interest are three factors: culture group, residence time, and first- and second-order variability in flooding extent, duration, intensity, and predictability. Culture groups having greater environmental knowledge of a particular fluvial system or a similar one may react very differently to these flooding events. This finding is further amplified by the importance of residence time of an individual, household, or social network in a given fluvial geomorphic unit, revealing the stark realization that migration, whether forced or voluntary, may act to impede resilience. Satellite, household, and ancillary data indicate high first- and second-order variability in many of the sites studied, framing climatic influences and synchronization of climate-driven precipitation and flooding as cause for incorporating the social with the fluvial and the political with the hydrological in an ethnofluvial geomorphic framework aimed at promoting policy alternatives for communities struggling to practice resilience.

LiDAR-Based Geomorphology of the Belize-Guatemala Transboundary Area: Legacies of Anthropogenic and Climate Changes in a Fluviokarst System

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Geomorphic research on the fluviokarst watersheds of the Belize-Guatemala Transboundary region is limited, despite the region's prominence in Maya history. This research suggests large scale ancient Maya impacts on this system, but impacts may be part of largely natural geomorphic factors like adjustments to climate or uplift. Our studies are quantifying to what extent human land use may have changed erosion rates and aggradation. Acquisition of LiDAR for this region allowed us to begin to assess the long-term anthropogenic vs natural factors. We used LiDAR to map the geomorphology of this river system and identify sampling sites in proximity to both Maya sites and relict river channels. Field data show evidence of large flood events that transported cobbles up to 52 cm in diameter, and particle size analysis indicates presence of non-local coarse sands that originated in the distant Maya Mountains. These flood sediments are intermingled with Maya activity layers, which we are dating from radiocarbon samples and artifacts.

Magnetic susceptibility readings help confirm the presence of well-developed burned paleosols beneath cobble layers, showing the long-term human land use in this region. We are using a whole suite of further lab analyses to characterize the sediments, and correlating our emerging fluvial history with existing paleoclimate data and other environmental records. These data will help further elucidate anthropogenic and climatic factors of landscape change, potentially offering important insight into modern environmental management for conservation and for natural hazards like flooding, both highly relevant in the increasingly populated tropics of Central America.

Streamflow variability within four rivers in the eastern highland rim region of Tennessee

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Intermittent rivers, defined as all rivers that naturally and periodically cease to flow, are found on every continent and may be more common than perennial rivers characterized by continuous flow. Recent research has shown the considerable differences between intermittent and perennial rivers. The extent to which geology, topography, vegetation, and climate influence intermittent streamflow patterns, streamflow variability, and runoff response remains largely unknown. Here we examine three intermittent rivers and one perennial river by deploying 36 stream, temperature, intermittency, and conductivity sensors (STiCs) to determine influences on streamflow patterns, focusing mainly on geological and topographic effects. Data were collected over the course of 1.5 years at 60 minute intervals within each of the rivers. From these data, we produced a set of streamflow metrics that describe flow conditions over time. We found upstream sections of rivers flowed continuously, while the downstream sections immediately following waterfalls dried for a portion of the year. Further, the upstream sections recorded higher relative resistivity readings than the downstream sections. The data collected via STiCs demonstrate that Eastern Highland Rim rivers behave abnormally compared to the normal drying behavior of most intermittent rivers. Our results illustrate a correlation between occurrence of waterfalls and spatial variability in streamflow patterns as demonstrated in each of the observed rivers.

Quantifying ancient Maya impacts on the geomorphology of tropical wetlands using airborne LiDAR

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A breakthrough technology that has exponentially improved our ability to understand the scope of long-term human impacts on the earth is Light Detection and Ranging (LiDAR). This study presents preliminary analysis of LiDAR data for studying the long-term effects of ancient Maya ecosystem engineering in tropical wetlands. Our research area is a seasonally inundated wetland in the Rio Bravo fluviokarst watershed in Northwest Belize. This

analysis reveals, for the first time ever, extensive networks of wetland canal systems and agricultural terraces below the canopy surrounding Maya archaeological sites. Evidence from a subsample of these agricultural and water manage features indicate they date from 2000 to 1000 years before present when the Maya abandoned these intensive landscape modifications. We used airborne LiDAR data to derive bare-earth, slope, and local relief models at 0.5-meter resolution. We then compared various automated methods to quantify morphometrics and extent of ancient Maya canal and raised field agricultural systems at the Maya site of Birds of Paradise. The results reveal an unprecedented scale of ancient wetland agriculture that has left a geomorphic imprint on the landscape even with 1000 years of regrowth after abandonment. These discoveries have profound implications for understanding the beginning of the Anthropocene, and the potential impacts of modern resource management.

Interactions between cohune palm (Attalea cohune) monodominant forests and soils

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Cohune palms (Attalea cohune) form monodominant stands, and consequently affect forest composition, forest heterogeneity, and soil morphology throughout Mesoamerica. Scientists have long noted the association of these palm stands with deep and highly organic soils. Yet, we know little about the provenance and broader ecological implications of this dominance. We investigated soil and geomorphological factors connected with cohune palm stands in northwestern Belize. Previous work indicated that cohune palm forests are associated with deep A horizons and high organic content throughout their soil sequences, and possibly increased silica content. The 2017 field season added four more soil sequences to this work, from three different cohune palm forest stands. We combine this intensive soil sampling with data derived from a recent LiDAR acquisition, in order to investigate the interactions between cohune palm forests and the local geomorphology. Our goal is to clarify the origins of cohune forests; as well as, monodominant stands' effect on associated environments, contributing to broader questions concerning tropical forest composition and function.

A web-based GIS utility for multi geomorphic hazards mapping and visualization- case study: Kan Basin, Tehran City, Iran

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One of the most important components of hazard risk management is providing planners, engineers, and managers with accurate information. Since the planning process is the result of understanding and interpreting information of natural and human systems, clear representation of hazard data and the relationships between them allows planners to identify suitable and efficient levels of intervention. In this regard, web-mapping applications can visualize the entire single hazard layers' information without loss of content, while at the same time the user is free to choose any hazard or risk combination within a

predefined area. Herein, a visualization scheme was developed and automated using HTML, CSS, JavaScript, and the ArcGIS JavaScript API to prevent the user from having to open each of the result layers in a desktop GIS application and define colors, patterns, and symbols. This application improves the basic display of information by layers and legend controls, query functions and a transect tool, which allows the user to explore the elevation of each hazard and have a general perception of the spatial pattern of hazards within the defined area. The resulting application can be used as a suitable tool to mitigate difficulties in combinability and comparability of single-hazard analysis results and interpretation of multi-hazard maps.

Using resilience theory to study the hydrogeological character of the Upper Camp Bird III Rock Glacier, San Juan Mountains, Colorado

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Global change is impacting rock glaciers and the permafrost-fed hydrology throughout the San Juan Mountains. Because melting ice in these rock glaciers is primarily responsible for sustaining stream flow, we employed resilience theory to create a dynamic model of the hydrology of a typical rock glacier from the San Juan Mountains to aid in understanding future pathways. We identified stages of release, exploitation, conservation, and reorganization associated with the rock glacier. Climatic warming since the late Pleistocene has produced an accumulation of rock debris covering an ice mass within the rock glacier. These changing conditions have also resulted in the propagation of disturbances through the rock glacier producing longitudinal furrows and transverse ridges, as well as ponded surface waters. This stage is characteristic of rapid colonization of recent disturbed areas within a rock glacier. Cirques supply energy and mass for a new rock glacier system. Thus, the new rock glacier system with its numerous ridges, furrows and talus streams, resembles the original rock glacier but has new functional characteristics as piggybacking lobes that represent multiple stable states. To obtain a detailed representation of the internal structure and determine the boundaries between resistive and conductive materials of the rock glacier, time-domain and frequency- domain electromagnetic induction methods were implemented. The use of two different systems provides continuity across the data sets and helps validate data collected using this novel approach. This study emphasizes the role of change and the importance of the various nested hierarchies in the hydrology of rock glaciers.

Win-win? The tradeoffs of floodplain reconnection along the Illinois River

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Like many rivers, the Illinois was heavily altered to facilitate navigation as well as flood protection and agricultural development. While these alterations and projects have been largely successful in accomplishing their goals, they have negatively impacted river-floodplain ecology while flood water surface elevations have continued to increase over the last decade. These increasing flood heights threaten levee districts and communities along the Illinois and also result in agricultural losses when rural levees are overtopped. Recent studies have advocated for reconnecting parts of the Lower Illinois River to its floodplain in order to drive down flood risk while subsequently increasing habitat for species that have been negatively impacted by changing the Illinois' natural hydrologic and hydraulic regimes. This study presents several scenarios and analyses of levee districts to determine which floodplain areas would provide the highest level of habitat benefits under reconnection. The costs of implementing levee setback and removal scenarios and their corresponding water surface elevation reductions were quantified. Overall, there was no correlation found between agricultural profit and levee districts' flood protection levels. Along the Lower Illinois, there are major tradeoffs under reconnection scenarios due to upstream and mid-reach districts having the highest floodplain habitat potential, while infrastructure and flood risk benefits were maximized by changing downstream levee configurations. To implement the modeled scenarios, payments for ecosystem services would likely be necessary to balance out reconnection costs that exceed $659 million.

An evaluation of streambed response

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The response of streambeds to flood events is key to understanding the trajectories of river channel change. This study characterizes temporal trajectories of bed adjustment in Carnation Creek, a gravel-bed river located on the west coast of Vancouver Island, British Columbia. In the 900 m long study reach, bankfull width and depth averages 15.8 ± 0.8 m and 0.85 ± 0.04 m, respectively. Surface sediment is typically 1.6 times coarser than underlying sediment based on the median diameter. Large woody debris present in the channel originates from natural processes and previous logging activities. Bed response was repeatedly measured between 1991 and 2007 using cross-sectional survey and scour indicators. Scour indicators were installed along multiple channel transects in four subreaches, which were also surveyed. This analysis focuses on the streambed locations of 82 scour indicators where bed elevation was documented over time. Trajectories of streambed adjustment exhibit two trends. In one subreach, the temporal pattern in bed elevation suggests resilience because, on a mean basis, the bed approaches the initial condition after an adjustment. In the other subreaches, however, bed elevation exhibits an increasing departure from initial conditions over time. These outcomes appear to reflect, in part, local controls over sediment transfers during floods. Overall results indicate that within a relatively short length of channel bed response can follow distinct trajectories over the timescale of two decades.

Geomorphic Controls on Riparian Forest Response to a Catastrophic Flood in Mark Twain National Forest, Missouri

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Riparian forests can act as both a cause and effect of geomorphic change due to flood disturbance. In the Ozarks Highlands the effects of flood events on stream channel morphology and adjacent riparian forests are not well understood. Therefore, the purpose of this study is to examine the geomorphic response of the North Fork of the White River in the Missouri Ozarks to a "1,000-year" flood event which occurred in April-May 2017. The main objective is to analyze the spatial distribution and characteristics of standing, toppled/rooted, downed, and transported trees across vegetated bars and sub-bankfull benches. All trees greater than 0.15 meters diameter breast height and 2 m long were located by GPS and characterized according to orientation, size, and condition. Results will describe patterns of forest disturbance including tree mortality, hydraulic factors, and geomorphic effects. This study presents preliminary results of a NSF-RAPID project to monitor the impacts and recovery of Ozark river systems to floods.

The impacts of Tropical Storm Cindy on a study site at McFaddin National Wildlife Refuge, Texas

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Field work conducted at McFaddin National Wildlife Refuge, Texas coincided with the landfall of Tropical Storm Cindy in June 2017. It is known that powerful hurricanes can serve as geologic agents on coastal marshes along the Gulf Coast in Southeast Texas; however, there is a paucity of information on how small tropical storms impact the coastal marshes of this region. The arrival of Tropical Storm Cindy presented a serendipitous opportunity to document how a small tropical storm impacts a study site on McFaddin National Wildlife Refuge. Photography and on-the-ground field exploration were used to document these effects. Results indicate that the storm surge was too small to deposit any sediment onto the marsh. This result is valuable and adds to the body of knowledge regarding how the dynamics of tropical cyclone strength and storm surge height influence storm surge sedimentation.

The Geomorphic Origin and Evolution of Grand Valley, western Colorado: a New Investigation

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Although the Uncompahgre Plateau, Unaweep Canyon, and Colorado and Gunnison rivers have received much attention focusing on their origins and evolutions during the past several decades, Grand Valley, unfortunately, has received insufficient attention. Previous hypotheses suggest that the evolutionary history of the valley is the result of avulsions of the Colorado River, whereas another hypothesis suggests glacial outwash as partly responsible for its evolution. The relatively flat terrain of Grand Valley (w ~ 7 km) contrasts markedly to the lateral extent of the Colorado River channel (w <1 km) flowing through Grand Valley. Because of the close proximity of Grand Mesa, ice capped during the Pleistocene, we hypothesize glacial meltwaters were responsible for valley formation. To address this hypothesis, numerous surrogates will be examined: four sets of fluvial terraces will be dated using optically stimulated luminescence dating (OSL) to correlate the relationship of the terraces to interglacial times. The subsurface of Grand Valley will be seismically surveyed for paleochannels to determine the contact between the alluvium and the substrate, which will help evaluate whether the Colorado River in the vicinity of the Grand Junction area played a major part in the valley genesis. Samples of alluvium from Grand Valley and upstream to Grand Mesa will be used to delineate provenance. If glacial flooding has much to do with the origin and evolution of Grand Valley, as we contend, then this study may be crucial for predicting alpine flood hazards, as related to global change and relatedly their mitigation.

A review of biotic roles in disturbance induced regime shifts of geomorphic systems

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Disturbances are critical to Earth surface system function, maintenance and development. The behavioral regime of geomorphic systems may shift and adjust to disturbance events via scale associated complex responses. This project focuses on identifying biotic roles in disturbance induced behavioral regime shifts based on examples from the biogeomorphic literature. This review identifies three general relationships of biogeomorphic agents and processes with disturbance. Firstly, biotic agents can lead to the formation of biogeomorphic characteristic forms (BCF). Darwin's depiction of biomantle formation by soil fauna is a classic example of BCF. The first relationship, therefore, indicates that removal or alteration of 'biogeomorphic roles' can cause destruction, damage, or disruptions of characteristic forms as their persistence depends on biogeomorphic interactions. The second relationship addresses the effects of biotic processes on landscape sensitivity to disturbance, which depends on force and resistance, magnitude, frequency and duration, relaxation time, stability, and historical contingency. For example, Pawlik's (2013) indication of the role of trees on slope stabilization suggests higher resistance to disturbance and therefore, lower landscape sensitivity. Finally, some geomorphic disturbances arise directly from biotic disturbances. For instance, Beschta and Ripple (2012) showed the effect of large predators' disappearance, cascading through ecosystem trophic levels, on the regime shift of a river system — functioning as a biotic disturbance. Thus, biotic presence or absence itself has the potential to cause perturbations.

Using a resilience approach for susceptibility to mass movement in the western San Juan mountains, CO

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The San Juan Mountains (SJM) have a legacy of slope instability as a result of a complex geologic setting and rugged mountain topography. To unravel the impact of this mass movement system legacy, we used a resilience approach to identify the role and supply of change, in terms of mass and energy by focusing on the thresholds that are transformational. Analysis of the SJM over the past forty years, illustrates a pattern of episodic activity, suggesting mass movement activity has multiple equilibrium thresholds resulting in various types of mass movement that occur temporally and spatially non-uniform throughout the SJM. This fact makes classification attempts at a regional scale challenging. We approached each mass movement type as an adaptive system of nested spatial-temporal landform processes. These thresholds included slope and slope length, aspect, geology, vegetation cover, soil drainage, and climate. Our study of these mass movement features suggest that these nested hierarchies promote a stabilizing effect on slopes as the result of memory of past events allowing the form to accept recovery after change occurs. Not all change results in recovery. Strong mass and energy connections across scales can result in a destabilizing effect promoting small-scale manifestations to translate into large-scale events. Our GIS-based virtual 3-D resilience approach for susceptibility to mass movement in the San Juan Mountains suggests that critical scales are dynamic and uncertainties must be realized. From an applied perspective, system resilience can facilitate a learn-from-past-experiences approach, fundamental for institutions and society to accept and adopt.

Resilience of channel sediment quality in mining-contaminated streams, Galena River Watershed, WI-IL

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Stream sediment of the Galena River Watershed of southwest Wisconsin and northwest Illinois is heavily contaminated with zinc (Zn) and lead (Pb) from historical mining operations that were active during the early 1800s until 1979. Since 1979, there has been some effort to remediate mine waste in the watershed by private organizations and the Wisconsin and Illinois Departments of Natural Resources but the effectiveness of their efforts to reduce stream pollution is unknown. An objective of this research is to compare present-day (summer 2017) trends of sediment-metal contamination within the Galena River Watershed with past contamination trends reported 25 years ago. These trends will help assess the time of recovery as a result of mining inactivity, remediation efforts, and sediment mixing and dilution. This research will contribute to our understanding of the

spatial-temporal variability of contaminated sediments, linkages between geomorphic and geochemical processes, and resilience of historically mined watersheds.

Freshwater mussels as ecogeomorphic agents: Literature synthesis and development of an in-stream experiment

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Previous studies have regarded mussels as ecosystem engineers due to their interactions with sediments. Many studies that have focused on the capabilities of mussels to alter sediment properties have focused on marine mussels or have been conducted in flume settings. Less studies have focused on the potential biological influence of freshwater mussels on geomorphological processes in river habitats. Freshwater mussels may maintain or transform the physical stability of river substrate through processes including biodeposition, compaction, armoring, or bioturbation. Field based methods measuring river sediment modification by freshwater mussels are needed to better understand biophysical processes in rivers, and the potential of freshwater mussels to maintain resiliency in river systems. As a first step to understand the potential of freshwater mussels to influence reach-scale geomorphic processes, we developed an in-stream mussel enclosure experiment and set of procedures to analyze the processes in which mussels influence micro-scale sediment properties and stability. We deployed 36 mussel enclosures in the Sipsey River, Alabama (USA) for a 9-week period, with different density and community structure treatments. We implemented sliding-bead monitors, an underwater photographic sieving method, modified particle size and smear slide analysis. In this poster, we present a literature synthesis of freshwater mussels as ecosystem engineers and the development of our method to assess the micro-scale interactions between freshwater mussels and sediment properties.

Paleoecology, genesis, and human manipulation of wetlands in Northwestern Belize

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Ongoing research on ancient Maya agriculture and prehistoric landscape modification enhances our knowledge of human resilience and resource extraction in the face of long term regional drought cycles and environmental change. In 2016, we conducted a Lidar survey of tropical forested wetlands in Northwestern Belize, which provided extensive new evidence of anthropogenically modified fluviokarst systems and wetland agricultural underneath the canopy. This Lidar coverage indicates an intensive modification of the environment, including upland terraces, wetland fields, and canal systems. Here, we present our current state of knowledge of one of these agricultural zones, the Birds of Paradise wetland, based on previous research and our new mapping and excavation efforts

from the summer 2017 field season. In this system, swamp genesis began with the transition of a floodplain soil to a wetland dating around 1675 years BP. A rising water table, either anthropogenically driven or naturally derived, caused peats and sediments to deposit on top of terrestrial soil. Pollen and isotope analyses shows that maize cultivation occurred over the duration of the Maya Classic (1650-1000 BP) and into the Postclassic as well, suggesting cultural resilience at that time. Evidence from nearby Maya mound excavations suggest that the ancient Maya exploited these wetlands for multiple uses at least until the Late Classic with a Postclassic reentry. Based on these multiple proxies and compared with regional climate records and Maya history, we consider the timing, duration, formation, and spatial extent of human use of these anthropogenic wetlands in this region.

Large alluvial rivers, vegetation, and past-present landscape biogeomorphic imprints

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Riparian and wetland landscapes are shaped by hydro-geomorphic processes. The vegetation types are influenced in their persistence and abundances by nonequilibrium disturbances associated with a set of hydro-geomorphologic processes. Landforms are derived from past events and legacies, but also by present active dynamics, and the species of plants in a given landscape are also the result of historical events and present transformation variables. There is always a tension in these kinds of studies between what can be explained in reference to current biophysical conditions, as contrasted with what must be inferred as due to events happening in the past areas of vegetation that occupy a position related to a particular geomorphologic unit and that differ from others in terms of geomorphic mosaic, floristic, pedologic, hydrologic and topographical composition can be defined as morpho-vegetation units. The morphovegetation mapping results in an environmental mosaic which can be identified in a variety of scales with Quaternary landforms dominantly controlling the distribution of vegetation units. Despite these concepts were broadly developed decades ago, the role of inactive landforms controlling the vegetation distribution had been not be recently considered by ecologist and vegetation specialist in the tropics. Using examples from the Amazon, Parana and other large alluvial plains we claim that combining the ecological information with an analysis of hydro-geomorphological processes, a reconstruction of the morpho-sedimentary Quaternary mosaic and the identification of morpho-vegetation units are appropriate ways to communicate and synthesize findings in ways that may be relevant for decision makers and conservation planners.

Geomorphic effects of an extreme flood in a karst mountain watershed, southwest coast, Jamaica

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The geomorphic effects of flooding on mountain streams in

Jamaica are poorly understood, particularly in the karstic watersheds along the southwest coast. This paper presents preliminary results on understanding the geomorphic effects of an extreme rainfall event and subsequent flood in Brighton-Bluehole watershed near Belmont, Westmoreland, Jamaica. The study area consists of approximately 1 km^2 of the lower part of the watershed. A tropical depression produced 32 cm of rain on June 12, 1979 resulting in channel incision, debris flows, and flooding in communities. This report describes watershed characteristics, channel and spring networks, and landforms. Geomorphic disturbances include the effects of past and present land use and high stream power generated by the flood. Debris flow deposits occurred below a segment of deep channel incision due to the failure of earthworks that filled a narrow valley. In the lower portion of the watershed, the stream system flows through a marsh and mangrove forest before emptying into Bluefields Bay, a no-take fish sanctuary. Residential construction is presently disturbing the mangroves which has raised local concerns since cultural beliefs hold that mangroves protection is important to the health of the local fishery.

Ecosystem services and damage costs of federal lands: Case study of Gila National Forest, USA

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Protected lands provide a wide range of benefits (i.e. ecosystem services) to multiple stakeholders across all scales, from local to global. This paper uses Gila National Forest (New Mexico, USA) as a case study to show the value of these ecosystem services and the damage costs associated with removing its protection from development. Total values for ecosystem services ranged from US$ 5,311 – 6,920 million annually. Damage costs from development of just 1.4% of Gila National Forest's total area were US$ 126 – 335 million. By using readily available data and trade-off analyses, this study illustrates the importance and value of ensuring that federal lands remain protected.

The geomorphic nature of mountain bike impacts on selected trails near Austin, Texas

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Mountain bike trails exist as physical manifestations of direct mountain biker forcing on the landscape. The geomorphic nature of these impacts was evaluated using innovative techniques with accelerometer data as a proxy for mountain biker forcing. Mountain biker forcing variables and landscape scale variables including topography, vegetation cover, and soil type and texture were evaluated in regard to their influence on trail morphology. Trail systems in the Austin, Texas area were used for the study. Each trail system had different trail user groups and management requirements. Trail morphology was found to be correlated with trail user forcing as documented by accelerometers and other movement variables such as speed and turn angles. Trail morphology was shown to be influenced by vegetation cover and soil type and texture. Trail morphology was also influenced by land management requirements introducing a political component to geomorphic change. Mountain biker generated forcing was most correlated with trail

morphology at trails which had higher mountain bike traffic relative to other user groups. Overall use rates, independent of user type, were most influential on trail morphology. Further research is needed to gain better resolution for accelerometer data by sampling riders of various skill levels. As a proof-of-concept project this research provides an entry point for research about the geomorphic nature of mountain bike trails.

Catastrophic flood disturbance and a community's response to plant resilience in the heart of the Texas Hill Country

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The Blanco River, which flows through the limestone Balcones Canyonlands of central Texas (USA), experienced catastrophic flooding in May 2015 that resulted in significant biogeomorphic disturbance to its riparian corridor. High-resolution aerial and satellite imagery from pre- and post-flooding for a 55-km reach of river were used to map and categorize patterns of disturbance by degree of severity ranging from complete floodplain stripping to no disturbance. The most severe disturbance occurred within the floodway near the channel and decreased with lateral distance into the 100- and 500-year floodplains. Disturbance patterns previously identified in the literature including meander scour, parallel chute scour, convex bank erosion, and macroturbulent scour were all present following this event, as well as substantial disturbance proximal to tributary confluences. In the aftermath of this event, TreeFolks, a local nonprofit organization, engaged with the community to actively replant and restore the riparian corridor of the Blanco River on public and private lands. These reforestation efforts supplement the natural passive recovery of the riparian corridor, enabling the system to recover more quickly and be resilient to future flood events.

Modelling the support factor (P) as a function of socio-economic factors for improved erosion prediction in the Lake Victoria Basin of Uganda

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During erosion assessment the support factor (P) is very uncertain to parameterize. P is usually regarded as 1 where no structural management practices exist; and in land uses with agronomic practices, it is hardly known. Moreover, the latter are simple and affordable technological innovations that can enhance ecosystems resilience to runoff and soil loss in Uganda. Our objective was to model the support factor (P) as a function of socio-economic factors for adoption of management practices in order to improve erosion prediction. We obtained a functional relationship that represent how soil surface conditions affect flow paths and flow hydraulics in the Lake Victoria Basin. Then we evaluated the existing management practices on soil loss reduction on Acric Ferralsols on agricultural land by integrating the functional relationship with the RUSLE. Results showed that at slope gradient 10-15% the potential erosion as predicted by RUSLE

was 120-140 t ha-1yr-1. While soil loss from where P was modelled as a function of socio-economic factors for adoption of management interventions was 11-50 t ha-1yr-1. This accounted for about 67-90% reduction in soil loss from the maximum potential erosion as predicted by RUSLE. In conclusion, the P factor affects erosion potential. Its uncertainty can easily be overcome by this approach.

Geomorphic response to a catastrophic flood event, North Fork of the White River, Missouri Ozarks

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In-steam large wood structures have been widely used in the Pacific Northwest as a river restoration technique. However, large wood structures have not been used in the Ozarks until recently. In October 2016 the U.S. Forest Service installed four engineered log structures (ELSs) to stabilize banks at the North Fork Recreation Area in Ozark County, Missouri. On April 30, 2017 a catastrophic flood event occurred with a stage that reached approximately 14 feet above the previous record flood in 1985. The flood destroyed a highway bridge at the North Fork Recreation Area, and another highway bridge close to the mouth of the river at Norfork Lake. The objectives of this study are to compare pre-flood and post- flood surveys to: 1) analyze changes to bed and bank landforms, 2) determine large woody debris volume, and 3) evaluate the effectiveness of the ELSs. Preliminary results show that there was a planform change where the thalweg position moved to the opposite side of the channel, large woody debris increased throughout the study reach, and deposition around the ELSs was maximized by approximately 3.4m. The importance of this study is to understand how a catastrophic flood event affects localized geomorphology and evaluate the use of large wood as a restoration tool in the Missouri Ozarks.

Eco-geomorphic feedbacks stimulated by benthic macrofauna in streams: A review and current research with burrowing bivalves

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Traditionally, research on eco-geomorphic interactions in streams suggests system resiliency is directed unilaterally with abiotic forces driving biotic systems. Researchers now recognize the need to incorporate a framework that acknowledges feedbacks between the biotic and abiotic realms of a watershed. Here, we examine such eco-geomorphic feedbacks stimulated by a group of obscure aquatic organisms: benthic macrofauna (mollusks, crustaceans, insects, worms). Benthic macrofauna stimulate eco-geomorphic feedbacks through their ability to sustain consistent, low-impact alterations that can have lasting effects on a watershed. These alterations manifest through the role benthic macrofauna play in cycling sediment and nutrients, facilitating benthic-pelagic coupling that connects food webs and concentrates nutrients and bioavailable carbon that would otherwise be lost downstream. By connecting food webs, benthic macrofauna provide bottom-up provisioning of energy and nutrient flow that can be traced to pelagic and riparian zones in

a watershed. By concentrating nutrients and carbon in the benthos, benthic macrofauna have the potential to influence streambed stability through physical and ecological processes. We suggest these processes facilitate feedbacks with the abiotic environment that can lead to alteration of flow, erosion and sedimentation. Further, we suggest these small-scale alterations, compounded over time between disturbance events (i.e. under baseflow conditions), can result in channel alteration on the reach- and watershed-scale. Here, we provide a literature review highlighting examples of eco-geomorphic feedbacks stimulated by benthic macrofauna in streams, present current research on the subject using burrowing bivalve aggregations as a framework, and conclude with implications of benthic macrofauna-induced eco-geomorphic feedbacks on stream resiliency.

Gorillas as earth-movers: Identifying zoogeomorphic hotspots in Equatorial Africa

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Gorillas (Gorillas ssp.) are among the most charismatic and well- researched species on the planet, yet their role as zoogeomorphic agents has gone largely overlooked. Zoogeomorphology is the study of animals as geomorphic agents, that is, the role they play in direct earth surface modification. The complexity of gorilla social systems, behaviors, and their phylogenetic relationship with human hominoids (approximately 98.3% of gorilla genetic code is shared with humans) drives research across multiple disciplines. Key ecological implications primarily center on endozoochory and forest structure maintenance but little attention has been given to their role as zoogeomorphic agents. A greater understanding of Gorilla spp. as earth modifiers is necessary to corroborate their role as keystone species and physical ecosystem engineers. Without this knowledge, vital pieces of information could be excluded in future conservation planning. This study will set the groundwork for further exploration into the zoogeomorphic impact of gorillas by identifying zoogeomorphic hotspots in Equatorial Africa. Soil-scratching traces; insect mound excavation sites; foot and knuckle prints; bare/semi-bare soil bottom terrestrial nest sites; and holes and caves created from soil-digging, geophagy, and tool use are the signatures identified for this study. The use of geographic information techniques (GIS) will be used to provide a visual representation of signature distribution with respect to vegetation, slope, and geology to identify gorilla zoogeomorphic target sites across sub-species populations.

Modeling debris cascades in the San Juan Mountains, Colorado: A preliminary graph theory approach

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Mass movement is the major geomorphic operating process in the San Juan Mountains of Southwestern Colorado. Field observations suggest an episodic transport of debris from higher elevations to lower elevations via various mass movement

processes. These deposits have been studied from the early 1900's to the present. Unfortunately, many major questions remain. In order to answer some of these questions we decided to use a new approach of graph theory to characterize mass movement in the San Juan Mountains. We envisioned the mass movement to be a system made up of various components and focused on the debris cascade. We utilized graph theory to model the relationships between system components. Because a graph consists of vertices, nodes, edges and arcs, we represent and analyze the connectivity between the said components. Thus, we can identify the properties and characterize the dynamics of this cascading system. We have also identified the various sediment sources including pathways, sinks and trajectories. We also used graphs to measure the relative influence of the different types of mass movement and to explore the debris dispersal in the area. We employed graph theory to describe whether concurrent variables operate independently or in concert. We further implemented the graph theory to determine the dominance of specific mass movement processes, in other words, whether a particular process can influence the activity of another process. In an attempt to understand the overall debris cascade we applied the graphs to model whether specific mass movement processes work together in definite ways.

Application of hydro-geomorphic principles to the management of terrestrial sediment loading rates into coral-bearing waters

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Curbing the effects of human-induced increases on terrestrial sediment delivery into coral-sustaining waters is a priority of coral reef management strategies in both the Pacific and Caribbean basins. Although research has achieved key advances in quantifying the degree to which various land use practices affect sediment delivery, most work has relied on a straightforward sediment budget approach that quantifies sediment contributions at annual scales. However, experimental research has determined that coral polyps and colonies may respond unfavorably to heightened sediment exposure levels at much shorter temporal scales. This poster represents an initial attempt at addressing not only the magnitude of runoff and sediment delivery to coastal waters but also their frequency. Here, I evaluate empirical runoff response data to assess the impacts of storm size, spatially explicit levels of disturbance, catchment size, and mitigation strategies under the lens of hydro-geomorphic concepts such as active/contributing areas, volume-to-breakthrough, and connectivity. Changes in runoff response are here proven relevant in dry tropical areas of the Northeastern Caribbean drained by ephemeral channels where small catchment size allows for measurable changes in runoff and sediment response even under limited disturbance levels. Elucidating whether these alterations are pertinent to coral reef conditions will require research based on truly interdisciplinary questions.

Channel stability and sediment budget analysis of a human modified channel system in the Missouri Ozarks

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Marc Owen, Robert T. Pavlowsky
Missouri State University

A sediment budget approach is used to evaluate the impact of channelization on the geomorphic stability of headwater streams in Mark Twain National Forest in the Missouri Ozarks. Big Barren Watershed is composed of 90% federal lands with private in-holdings typically located in wider stream valleys to access fertile bottomlands for grazing and hay production. The natural channel form is relatively wide and shallow with riparian forest growth on floodplains and often on channel beds with floods typically spreading out across the valley floor. To improve drainage, landowners excavated channel beds and raised levees. Increased channel depth and capacity, and reduced roughness resulted in large head-cuts migrating up stream and sandy sediment pulses aggrading downstream channels. This study evaluates the volumes of sediment excavated, eroded, and deposited due to human activities in comparison to other geologic/natural process in upper Big Barren watershed (9 km^2). Multiple cross-section and sediment depth measurements were used to quantify the distribution and volume of geomorphic change. Since stream channelization usually extends to forest boundaries, migrating disturbances caused by private land management practices are often responsible for the degradation of riparian zones on public lands.

Hydrologic effects of prescribed burning in Mark Twain National Forest, Missouri

#Roman, Grace, Megan Hente, Joe Nash, Marc Owen, Robert T. Pavlowsky
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Prescribed burning is a land management tool used throughout North America in both the private and public sector. In 2006, the United States Forest Service implemented prescribed burning in the Mark Twain National Forest in the Ozarks Highlands of southeast Missouri to improve forest health, benefit native species, and control fuel loading. The public voiced concerns that burning increased runoff from forest lands and caused downstream flooding on private lands. In 2015, we began to monitor runoff in the national forest on the main stem and tributaries of Big Barren Creek Watershed (191 km^2) to evaluate burning effects on forest hydrology using a network of level logger gaging stations. Site drainage areas ranged from 1.7km^2 – 51.1 km^2 and stage data was recorded in five-minute intervals. Results indicate that runoff trends in Ozark headwater streams vary with network characteristics and karst influence. However, average runoff yields and hydrograph shapes are similar for both burned and unburned areas. Moreover, increased precipitation intensity over the past decade, possibly due to climate change, may be the cause of flooding problems.

Influence of neighborhood history on metal concentrations in roadside soils and street dusts, Springfield, Missouri

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Urban watersheds can be exposed to toxic concentrations of metals in stream sediments and soils due to releases from past

chemical applications and industrial emissions. It is considered unsafe for human exposure if soils in residential areas contain >1,200 ppm lead (Pb). Soil Pb concentrations of 400 ppm within children's play areas pose a risk to the central nervous system and brain development in children. This study assesses Pb, Zn, and Cu levels in roadside soils and road sediments in Springfield, Missouri. Sampling was stratified between two neighborhoods, an industrial area, and a stream. These areas were established at different times and had varying levels of traffic use. An XRF analyzer was used to measure heavy metals. Both road soil and sediment samples were collected from each site. There were 13 sites collected from an older neighborhood settled 100 years ago, 10 sites from a younger area settled in the 1980s, 14 sites in the industrial area, and 3 sites in streams. The highest Pb concentrations were found in the older neighborhood. Maximum Pb concentrations in older areas exceeded 800 ppm for soil and 180 ppm for sediment. In comparison, maximum Pb concentrations in the younger neighborhood were >70 ppm for soil and >100 ppm for sediment. The third location exceeded 300 ppm for soil and >600 ppm in road side sediment. The highest concentration detected was 1,677 ppm Pb in a soil sample located along a commercial strip on the edge of the older neighborhood along a major road. Only two soil samples from the old neighborhood and none from the newer area exceeded the 400 ppm Pb limit which suggests a minimal health risk among the sites evaluated.

In-cave hydrology in VA and TX and differences in vadose storage properties: Differences in baseflow and hydraulic resilience of small tributaries after drought

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Long-term data collection at multiple sites in VA and TX show that karst systems developed in low-porosity fractured Paleozoic carbonates in western VA respond differently to hydrologic stressors than those formed in the relatively porous Cretaceous carbonates of central TX. Both systems have well-developed epikarst, with deep soil/sediment/residuum-filled fractures, bedding planes, and dissolution features. Using hydrologic and geologic evidence, and geochemical and isotopic data, we conclude that the differences in the two systems are primarily the result of storage in vadose zone bedrock matrix and fracture/bedding porosity. Overall, vadose zone storage is depleted at a faster rate in VA than in TX. Springs may cease flowing during extended droughts, but this does not mean that all water is drained from the vadose zone. Although VA systems cease flowing sooner, biological evidence suggests that the bedrock properties there result in isolated perched vadose waters that are maintained for extended periods of time. Stygobitic (aquatic cave-adapted) organisms are abundant in the VA zone systems – as determined by drip-water sampling in caves. In contrast, more limited drip-water sampling in TX has yet to yield stygobitic organisms, which supports the notion that storage in these systems during long-term droughts may be primarily in matrix rather than perched 'pools' in the epikarst.

These findings suggest that groundwater-dependent systems in TX may actually be more resilient to multi-year droughts, in terms of spring hydrology and ecology, than those in VA, and that karst springs have likely been more permanent in TX than in VA, despite the generally dryer conditions.

Impact of spring-associated riparian vegetation on channel morphology and sediment distribution in ephemeral dryland channels: Henry Mountains, Utah, USA

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Riparian vegetation has been shown to have an important effect on channel morphology and in-channel sediment distribution via its influence on hydraulics and sediment dynamics. It is difficult, however, to study variable vegetation in natural systems without using multiple field sites and, consequently, also introducing variation in flow conditions and sediment fluxes. In order to isolate the impact vegetation has on channel morphology, single channels that are not uniformly vegetated along their length are desirable for study, because it can be assumed that flow conditions and long-term sediment flux are consistent between major tributaries. Dryland flash flood channels provide an excellent natural laboratory to effectively isolate riparian vegetation as a variable and examine how its presence affects channel evolution. In these environments, widespread vegetation only exists just downstream of springs that discharge at lithologic contacts and thus remain relatively fixed in space on long timescales. Densely vegetated reaches in these channels can be assumed to have experienced similar flow and sediment flux conditions to non-vegetated or sparsely-vegetated adjacent reaches upstream or downstream, and any significant differences in channel morphology and sediment distribution can be attributed to differences in degree of vegetation. Two lidar datasets for the Henry Mountains in southern Utah, flown by NCALM in 2008 and 2011, provide an opportunity to determine how persistent vegetation patches in the channels described above have affected channel development. Additionally, implementation of Terrestrial Laser Scanning systems in the field allows for analysis at smaller scales and correlation of morphological phenomena with vegetation metrics.

Paleoflood investigations and physiographic characteristics associated with susceptibility to flooding in the mountainous Colorado Front Range

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Extreme precipitation and subsequent flooding events are the most prevalent and costly natural hazard globally (Baker, Webb, House, 2002). Therefore, it is necessary to better understand the physiographic characteristics associated with flooding to prepare for flooding hazards, since these factors are the dominant controls for flood runoff (Costa, 1987; Ebel et al., 2015). The Colorado Front Range is particularly prone to flooding hazards due to the steep, complex terrain of the mountains where waters quickly spill out onto the most populated region of Colorado along the Front Range (McKee and Doesken, 1997). This region has experienced numerous catastrophic flooding events, such as the 2013 Front Range Floods, the Fort Collins Flood of 1997, and the Big Thompson Canyon Flood of 1976 to name a few (NWS, n.d.). The objective of this study is to analyze the physiographic

characteristics of several drainage basins throughout the Colorado Front Range South Platte River tributaries and determine how these characteristics relate to extreme flooding susceptibility. This will be done through two parts: 1) data collection on the prior maximum observable flood through paleoflood analysis and historic records; and 2) a morphometric terrain analysis with ArcGIS. All basins without previous data collection on the prior maximum observable flood from paleoflood analysis will be analyzed through a paleoflood and historic analysis. The morphometric analysis will consider characteristics such as basin size, relief, orientation, etc. and compare these characteristics to flood magnitude for each basin to determine characteristics that most relate to extreme flood susceptibility.

Geomorphologic impacts and timeline reconstruction of Holocene Jökulhlaups along the Hvítá River and Gullfoss, Iceland

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Gullfoss is one of Iceland's most visited tourist sites, a two-tiered waterfall where the Hvítá River plunges 32 meters into the Hvítárgljúfur canyon. This system is one line of evidence for paleofloods that surged across the region ~9500 years BP. Over a span of 100-200 years, a series of floods drained the ice-dammed glacial lake Kjölur in the southwestern highlands. The largest events reached an estimated maximum peak discharge of 3 x $10^5 m^3 s^{-1}$, ranking them among the largest known floods in Iceland and on earth. Most research on Icelandic GLOFs (glacial lake outburst floods—also known as jökulhlaups) has focused on floods generated by volcanic and geothermal activity beneath the southernmost ice caps; but the little-studied Hvítá floods, not triggered by volcanogenic processes, may provide a better analog for most global GLOFs. A pioneering study by Tómasson (1993) reconstructed these paleofloods based on geomorphologic evidence, paleolake strandlines, tephrochronology, and sedimentology. This project builds on previous research by employing new methods to better constrain flood timing, magnitude, and routing. This poster has three main goals: 1) present new and synthesized geomorphologic field evidence along the estimated flood routes; 2) outline a sampling strategy for geochronological analysis; and 3) investigate post-flood landscape evolution. This research will yield insight into ice-dammed proglacial lake drainage dynamics, an increasingly important field in light of rapid climate-driven glacial lake expansion worldwide. It has excellent potential to bridge the gap between academic research and public outreach through communication to a high number of international visitors.

Seventy-five years after contour terracing on the Wasatch Plateau of Central Utah

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Overgrazing by sheep on the high plateaus of Utah in the late 1800s and early 1900s resulted in denuded landscapes susceptible to mass wasting and flash flooding following precipitation events. Many of these floods occurred on the Wasatch Plateau of Central Utah and resulted in loss of life and infrastructure. In an effort to mitigate these hazards, as well as

improve water retention, the United States Forest Service and the Civilian Conservation Corps, practiced contour terracing in the 1930 and 40s at high elevations across the plateau. The erosion control lines have been successful in reducing dangerous and costly flash flooding, but scant information exists on the present state of terracing. Fieldwork and aerial imagery analysis show that some terraces are now bisected by gullies with downward incision and erosion taking place. Additionally, terracing appears to have altered local hydrology as the position of surficial springs throughout the terraced areas appears to be related to the erosion control lines. Contour terracing has also affected fossorial mammal activity and ungulate game trails, both of which have been shown as significant biogeomorphic agents in alpine regions. Additional research is needed to understand fully how terracing has affected erosion, local hydrology, and biogeomophic agent behavior, because population continues to grow at the base of the Wasatch Plateau and the region is becoming an important recreation area with increased human presence and pressure.

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Binghamton Geomorphology Symposium 2018

Syracuse University has been selected to host the 49th annual Binghamton Geomorphology Symposium on August 25-26, 2018.

This international conference brings together leading scholars in geomorphology and a themed topic. The topic of our symposium will be **Sediment complexity within geomorphological systems**.

OVERVIEW:

It has become a consensus that processes controlling sediment initiation, transport, and deposition are complex both in space and over time. Understanding the complexity of these processes at different spatial and temporal scales require collecting and analyzing data with different levels of detail, which may be achieved by using a variety of field, experimental, and modeling approaches, possibly combined with advanced technology such as remote sensing and sediment tracing and dating. New ideas and concepts out of these approaches often arise from interdisciplinary collaboration among scientists in geography, geology, environmental engineering, and other relevant disciplines. The 49th annual Binghamton Geomorphology Symposium provides a forum for innovative thinking and potential collaboration.

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LOCATION:

Maxwell Auditorium, Syracuse University, Syracuse, New York (USA)

FIELD TRIP:

August 24, 2018 (Onondaga Creek Watershed)

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