Zoogeomorphology & Ecosystem Engineering

The 42nd Annual Binghamton Geomorphology Symposium

October 21 – 23, 2011

University of South Alabama, Mobile, Alabama

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Texas State University-San Marcos

Zoogeomorphology and Ecosystem Engineering

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October 21 – 23, 2011

Conference Organizers:

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Conference Sponsors

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Dr. Mimi Fearn, Ms. Sherall Cornwell, Ms. Karen Jordan, Ms. Tela O'Rourke, and Mr. Donald Brinkman, Department of Earth Sciences, University of South Alabama

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10:15 – 10:45 Coffee Break & posters

10:45 – 11:15 Peter Meadows, Azra Meadows, John M.H. Murray: Biological modifiers of marine benthic seascapes: Their role as ecosystem engineers

11:15 – 11:45 Bernhard Statzner: Geomorphological implications of engineering bed sediments by lotic animals

11:45 – 12:15 Paul DeVries: Salmonid influences on rivers: A geomorphic fish tail

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Session III: Sediment Movement and Erosion from a Variety of Sources

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10:05 – 10:35 Joyce Lundberg, Donald A. McFarlane: Post-speleogenetic biogenic modification of Gomantong Caves, Sabah, Borneo

10:35 – 11:00 Coffee Break & Posters

11:00 – 11:30 Joseph Hupy, Thomas Koehler: Modern warfare as a significant form of zoogeomorphic disturbance upon the landscape

11:30 – 12:00 David R. Butler: The Impact of climate change on patterns of zoogeomorphological influence: Examples from the Rocky Mountains of the western U.S.A.

12:00 Poster take down

12:15 – 2:00 Lunch and Discussion – Fresh Food Company (i.e. Campus Dining Hall)

2:00 Adjourn

Note: All paper and poster sessions will be held in the Humanities South Building.

Paper Session Moderators

Session I: David Butler and Clayton Whitesides

Session II: Richard Marston and Stephen Tsikalas

Session III: Melanie Stine and John Vitek

Introduction

David R. Butler* and Carol F. Sawyer **
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Animals modify and sculpt the land surface and produce changes in the environments in which they live. The significance of the geomorphic impact of animals was recognized early by key figures in the history of natural sciences and the discipline of geography, most notably with research projects by Charles Darwin (1881, earthworms) and William Morris Davis (1928, coral reefs). Scientists study the effect of a species in an ecosystem from different paradigms, based on their discipline. Geomorphologists analyze the amount of geomorphic work (*e.g.*, burrowing and trampling) done by a species in order to understand, model, and predict the effect that a specific species or specific action (i.e. digging) could have on landforms and sediment budgets across spatial and temporal scales. Ecologists also examine the role of animals on the landscape. They analyze the environmental changes that occur as a direct result of an animal's actions in order to understand, model, and predict the effect a species (and changes in the population of the species) could have on other species or the ecosystem at different spatial and temporal scales. In geomorphology, the study of the geomorphic effects of animals is called *zoogeomorphology* (Butler, 1992; 1995); whereas, in ecology, *ecosystem engineering* refers to the concept that habitats are created, modified, or maintained by organisms (Jones *et al.*, 1994, 1997). These two concept share commonalities; however, much research done in zoogeomorphology and ecosystem engineering has been "running parallel" to each other (for instance, researchers study burrowing, digging, and dam building from either an ecological or a geomorphological approach) without thoroughly integrating each other's work, or in some cases, without even being aware of the parallel research on the same species.

The purpose of the 42nd Annual Binghamton Geomorphology Symposium (BGS) is to bring scientists together from the fields of zoogeomorphology and ecosystem engineering who rarely attend or participate in the same conferences, to synthesize these two complementary concepts. The symposium continues BGS's long tradition of contributing to geomorphology; in particular, by focusing on the influence of animals on the modification of landforms and by treating animals as a geomorphic agent of change. The invited papers are being published in a special issue of *Geomorphology*, a major peer reviewed international journal (ISI Impact Factor 2.352), ensuring global dissemination of the current research presented at the conference and the people conducting the research. A broader impact of the symposium will be the increased awareness of the research occurring within the geomorphology and ecology disciplines, which may encourage increased future cooperation between researchers involved in examining the role animals play in modifying their environment. It is our hope that the 2011 Binghamton Geomorphology Symposium will provide a venue for researchers to examine the state of zoogeomorphology and ecosystem engineering, to foster communication between ecology and geomorphology researchers, and to discuss the hypotheses, conflicts, and current research on animals as geomorphic agents or ecological engineers.

References:

Butler, D.R., 1992. The grizzly bear as an erosional agent in mountainous terrain. *Zeitschrift für Geomorphologie*, 36(2): 179-189.

———, 1995. *Zoogeomorphology*. Cambridge University Press, New York, 239 pp.

Jones, C.G., Lawton, J.H. and Shachak, M., 1994. Organisms as ecosystem engineers. *Oikos*, 69: 373-386.

———, 1997. Positive and negative effects of organisms as physical ecosystem engineers. *Ecology*, 78(7): 1946-1957.

<u>Abstracts of Invited Presentations</u>*

(*Listed in order of presentation)

KEYNOTE ADDRESS

Microbial Geomorphology: A Neglected Link between Life and Landscape

Heather A. Viles

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Whilst recognition is increasing that life and landscapes are intimately related, as evidenced by growing research into ecosystem engineering, biogeomorphology and allied topics, the microbial contribution to such interactions has been relatively neglected. A revolution in environmental microbiology, based on molecular techniques, is now driving a reconsideration of the role of microbial processes in geomorphology at all scales. Recent research illustrates the hitherto unknown microbial diversity present in many extreme geomorphic environments, such as hyperarid deserts, subglacial lakes, hot springs, and much richer microbial life than previously suspected within the soils and sediments that blanket most other landscapes. Such microbial communities have been found to play important geomorphic roles across a wide range of environments, notably in weathering, precipitation of minerals and protecting surfaces from erosion. These geomorphic roles can also be conceptualised as examples of ecosystem engineering, and can pave the way for further plant-geomorphology and zoogeomorphology processes. Three key aspects which emerge from a review of microbial influences on Earth surface processes are a) that microbes play roles on a continuum from full control to passive involvement, b) that complex and widespread communities of microorganisms are involved and c) that microbial activity usually affects several Earth surface processes at once. Examples of the contribution of microbial life to geomorphology over long, medium and short timescales suggest that microorganisms play key geomorphological roles in two major situations; on the cusp between stable states, and in extreme environments where higher plant and animal life is limited and many abiotic processes are also constrained. The dominant link between microbial life and geomorphology appears to take on different forms depending on the timescale under consideration, with a stabilising microbial role apparent over short timescales being replaced by a denudational role over longer timescales. Further research involving microbiologists and geomorphologists is now needed to address three main questions, i.e. under what conditions are microbial and geomorphological processes most closely linked?, what scale issues surround links between microbes and geomorphology? And how do microbiological processes underpin broader biogeomorphological interactions?

Keywords: Microorganisms; Biogeomorphology; Ecosystem engineers; Lichens; Fungi; Algae; Bacteria

Citation:

Viles, H.A., Microbial geomorphology: A neglected link between life and landscape, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.03.021

Reconceptualising the Role of Organisms in the Erosion of Rock Coasts: A New Model

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*Presenter

Attempts to understand the morphodynamics of rock coasts focus on the nature and rate of erosion and how this influences the evolution of coastal profiles over century to millennial timescales. Biological contributions to this process are often ignored or treated in a rather simplistic way as merely producing microscale decreases in rock strength. Using a combination of field observations and literature review, we address two key issues hampering a more rounded assessment of biological impacts erosion of coastal rocks. Firstly, we reconceptualise the biological contributions to erosion of rock coasts into direct and facilitative types, and secondly we discuss the need for more appropriate reporting of rates of bioerosion. For direct bioerosion, this means clearly documenting the percentage of platform surfaces affected by bioerosive agents and quantifying the volume of material eroded and the amount of fine sediment produced. For facilitative bioerosion, we must quantify the roles of biota in changing the material properties of rocks, creating or altering surface morphologies and/or weakening joint boundaries. In this way, facilitative bioerosion is one of several processes mediating geomorphic alteration of rock surfaces, contributing to the production of landforms and/or reducing the resisting force of rock. Subsequently, we build on these ideas to produce a new conceptual model which more accurately portrays the multiple and cross-scalar ways that biological processes, notably bioerosion, influence the resistance of coastal rocks to erosive forces. Such a model provides a stronger basis for numerical modelling and understanding the morphodynamics of rock coasts in the future and allows a quantitative assessment of the role of biota.

Keywords: Bioerosion; Boring; Weathering; Biogeomorphology; Shore platform; Erosion

Citation:
Naylor, L.A., et al., Reconceptualising the role of organisms in the erosion of rock coasts: A new model, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.07.015

Biological Modifiers of Marine Benthic Seascapes: Their Role as Ecosystem Engineers

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Benthic organisms in marine ecosystems modify the environment on different spatial and temporal scales. These modifications, many of which are initially at a microscale, are likely to have large scale effects on benthic seascapes. This is especially so if the species are ecosystem engineers. Most species of infaunal and epifaunal invertebrates and macrophytes contribute at a geophysical or geochemical level. Microorganisms also play a key but currently neglected role. In the intertidal and immediately sublittoral zone, algae and seagrasses, and mussels in mussel beds have received considerable attention. A substantial fossil record also exists. Mathematical modelling of these systems is still in its infancy, although several sophisticated mathematical tools have been applied. The effects of bioturbation and of microorganisms have been less studied, and little is known about the activities of benthic organisms in the deep sea. This paper addresses all these effects, and places them in the context of large scale benthic seascapes and of the extensive literature on species defined as ecosystem engineers in the sea.

Keywords: Benthic; Marine; Sediments; Ecosystem engineers; Scales

Citation:
Meadows, P.S., et al., Biological modifiers of marine benthic seascapes: Their role as ecosystem engineers, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.07.007

Geomorphological Implications of Engineering Bed Sediments by Lotic Animals

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Recent developments in zoogeomorphology in combination with the increasing interest of ecologists in ecosystem engineering by organisms initiated considerable research on the impact of running water (i.e., lotic) animals (and other organisms) on fluvial bed sediments and the transport of solids. This research provided multiple evidence from field and laboratory observations and experiments that many species among mammals, amphibians, fish, insects, crustaceans, mollusks, and worms engineer bed sediments of running waters with diverse mechanistic “tools”, thereby perturbing or consolidating the sediments in many types of running waters across continents, seasons, habitat types, particle sizes, and discharge levels (baseflow vs. flood). Furthermore, many animals modify the bed-sediment engineering by plants (algae, larger macrophytes, riparian vegetation). Modeling effects of bioturbating lotic animals across species and relatively simple environmental conditions (in mesocosms) provided highly significant results (*P*-range: $< 10^{-6}$– $< 10^{-15}$) for nine sediment variables describing baseflow and flood-induced sediment transport as well as sediment surface modifications. For example, bioturbator biomass and/or algal abundance in combination with physical variables, such as baseflow shear stress or gravel size, explained between ~ 70 and ~ 90% of the variability in sediment responses such as the overall baseflow sediment transport and, as a result of the baseflow sediment-surface engineering by the animals, the flood-induced gravel or sand transport. Confronting these seemingly encouraging experimental results with real world conditions, however, illustrates considerable problems to unravel the complexity of biotic and physical factors that vary temporally and interfere/interact non-linearly in a patchy pattern in small parts of real river beds, where baseflow bed-sediment engineering by lotic animals prevents or fosters mass erosion during subsequent floods. Despite these complications, these problems must be solved, as bioturbators such as crayfish and bioconsolidators such as silk-spinning caddisflies may locally modify (i) rates of transport of fluvial sediments over three orders of magnitude and (ii) frequencies of mass transport events over five orders of magnitude. The fastest way to identify promising subsequent research routes in this field would be through a variety of abundance manipulations of lotic organisms (animals and plants having different mechanistic sediment-engineering abilities) in real rivers in combination with a simple approach to assess the critical shear stress in situ for varying types of sediments. This would require joint research by fluvial geomorphologists, hydrologists, and ecologists.

Keywords: Animal–plant-flow interactions; Bioconsolidation; Bioturbation; Sediment transport frequency; Sediment transport rate; Zoogeomorphology

Citation:
Statzner, B., Geomorphological implications of engineering bed sediments by lotic animals, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.03.022

Salmonid Influences on Rivers: A Geomorphic Fish Tail

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Studies of the effects of salmonids on the environment have focused primarily on the biological linkages between salmon runs and stream ecology. Less effort has focused on geomorphic effects. A review of the literature indicates potential (i) direct effects in response to mass spawning of salmonids, including changes in streambed and bank morphology and annual volumes of bedload transported; and (ii) indirect effects including supply of nutrients to the riparian zone, which may influence the in-channel dynamics of large woody debris and bank stability, and effects on population density of net-spinning caddisfly larvae which may influence streambed stability in finer gravel substrates. More research is needed over long time frames, however, to ascertain whether such effects are geomorphically significant at larger spatial and longer temporal scales, and to estimate the sizes of populations required to cause geomorphically significant responses. Some possible studies are suggested.

Keywords: Burrows; Ground-penetrating radar; Burrowing cascade; Ecosystem engineer

Citation:
DeVries, P., Salmonid influences on rivers: A geomorphic fish tail, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.04.040

KEYNOTE ADDRESS

Ecosystem Engineers and Geomorphological Signatures in Landscapes

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Biogeomorphologists study the roles of biota in landscape formation and decay. Ecologists interested in ecosystem engineering study environmental change caused by biota and the consequences for the engineer, other organisms, and ecological processes. The interface is geomorphological change, an interface both are aware of but study somewhat independently and differently. Interaction and integration among the two fields is the goal of this special issue. Here I take an ecological perspective of geomorphological change caused by ecosystem engineers in patches within landscapes that I hope can help facilitate this goal. I ask the following general questions: When will an ecosystem engineering species create a geomorphological signature in a landscape? What, in qualitative terms, is such a signature? How can the signature be estimated and how long will it last? What engineer attributes and ecological factors will determine signature change? What creates complications? How do the answers inform whether or not life leaves a geomorphological signature? To attempt answers, I develop a provisional, general theory of ecosystem engineering signatures that draws on and integrates a geomorphological foundation of balance between formation and decay; landscape patch dynamics; a general framework for ecosystem engineering; and empirical studies. I treat a landscape engineering signature as the balance of rates of formation (F) and rates of decay (D) across patches whose ratio value (F/D) can be transformed (> 1), intermediate (1) or untransformed (< 1). I suggest amenable systems for study. I describe how the signature can be estimated and evaluated for potential persistence, and how to identify when decay or engineer density and *per capita* engineering activity control the signature. I examine the influences on shifts from transformed to untransformed signatures, and *vice versa*, at constant and changing rates of decay. I show how the likelihood of signature shifts depends on: 1. engineer density in the landscape and per patch; 2. *per capita* engineering activity as structure per patch and patches per engineer, or its contribution for engineers occurring in groups; 3. the degree of patch maintenance, abandonment, and re-engineering of abandoned patches; and in some situations, 4. the direction of the signature shift that is considered. I use this to illustrate how different ecological factors affecting engineer species (e.g., abiotic resources and conditions, natural enemies) and engineer feedbacks can drive signature transitions. I address complications and how they might be dealt with for situations where an engineer species causes formation and decay; when multiple engineering species co-occur; and when patches are materially interconnected. I end by considering whether life leaves a geomorphological signature, using this to contrast my approach with biogeomorphology, and asking what a hypothetical analysis of signature patterns across many engineer species/landscape combinations might imply for the interface of ecology and biogeomorphology.

Keywords: Formation; Decay; Patch dynamics; Engineer attributes; Ecological factors

Citation:
Jones, C.G., Ecosystem engineers and geomorphological signatures in landscapes, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.04.039

The Role of Large Predators in Maintaining Riparian Plant Communities and River Morphology

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Studies assessing the potential for large predators to affect, *via* trophic cascades, the dynamics of riparian plant communities and the morphology of river channels have been largely absent in the scientific literature. Herein, we consider the results of recent studies involving three national parks in the western United States: Yellowstone, Olympic, and Zion. Within each park, key large predators were extirpated or displaced in the early 1900s and subsequent browsing pressure by native ungulates initiated long-term declines in recruitment (i.e., growth of seedlings/sprouts into tall saplings and trees) of palatable woody species and impairment of other resources. Channel responses to browsing-suppressed riparian vegetation included increased widths of active channels via accelerated bank erosion, erosion of floodplains and erraces, increased area of unvegetated alluvium, channel incision, and increased braiding. A reduced frequency of overbank flows indicated these rivers have become increasingly disconnected from historical floodplains because of channel widening/incision. Results from Zion National Park also identified major biodiversity affects (e.g., reduced abundance of plant and animal species). Although these studies were conducted in national parks, results may have implications concerning riparian plant communities, biodiversity, and channel morphology for streams and rivers draining other public lands in the western US. It is on these lands that native and introduced ungulates have often heavily utilized riparian areas, largely in the absence of key predators, with significant consequences to plant communities and channels.

Keywords: Channel morphology; Bank erosion; Riparian vegetation; Ungulates; Predators; Trophic cascades

Citation:
Beschta, R.L., Ripple, W.J., The role of large predators in maintaining riparian plant communities and river morphology, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.04.042

Elephants (and Extinct Relatives) as Earth-movers and Ecosystem Engineers

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Modern African elephants affect habitats and ecosystems in significant ways. They push over trees to feed on upper branches and often peel large sections of bark to eat. These destructive habits sometimes transform woody vegetation into grasslands. Systems of elephant trails may be used and re-used for centuries, and create incised features that extend for many kilometers on migration routes. Elephants, digging in search of water or mineral sediments, may remove several cubic meters of sediments in each excavation. Wallowing elephants may remove up to a cubic meter of pond sediments each time they visit water sources. Accumulations of elephant dung on frequented land surfaces may be over 2 kg per square meter. Elephant trampling, digging, and dust-bathing may reverse stratigraphy at archeological localities. This paper summarizes these types of effects on biotic, geomorphic, and paleontological features in modern-day landscapes, and also describes several fossil sites that indicate extinct proboscideans had very similar effects, such as major sediment disturbances.

Keywords: Proboscideans; Ecosystem engineering; Landscape sculpting

Citation:
Haynes, G., Elephants (and extinct relatives) as earth-movers and ecosystem engineers, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.04.045

Evidence for and Geomorphologic Consequences of a Reptilian Ecosystem Engineer: The Burrowing Cascade Initiated by the Gopher Tortoise

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Physical ecosystem engineers often make major, durable physical constructs that can provide living space for other species and can structure local animal communities over evolutionary time. In Florida, a medium sized chelonian, the Gopher Tortoise (*Gopherus polyphemus*) will excavate extensive subterranean chambers that can endure for long periods of time. The tortoise starts a 'burrowing cascade', by first excavating a larger burrow that may extend 10 m, which is then re-engineered by Florida Mice (*Podomys floridanus*) and other rodents that dig smaller side-burrows and pockets. This sequence is often followed by an invertebrate, the camel cricket (*Ceuthophilus labibuli*) which is reported to excavate even smaller chambers. Our first aim was to quantify the zoogeomorphic impact of this burrowing cascade by measuring the amount of soil excavated in a large sample of burrows in two communities. Secondly, we hypothesized that the high biodiversity reported for these structures might be related to the quasi-fractal nature of the geometry, following the work of Frontier (1987). To visualize this underground geometry, we used high-resolution 3D Ground Penetrating Radar (GPR), which provided images and insights previously unobtainable using excavations or 2D GPR. Our images verified that the active tortoise burrow had a spiraling shape, but also showed splits in the larger burrow apparently dug by tortoises. For the first time, the smaller Florida Mouse burrows were imaged, showing side loops that exit and re-renter the tortoise burrow. This study also presents new information by making the discovery of numerous remnants of past tortoise burrows deeper underground in the sampling grid surrounding the active burrow. Our third aim was to interpret our field results with previous ecological field studies to evaluate the strength of evidence that this species ranks as an ecosystem engineer.

Keywords: Burrows; Ground-penetrating radar; Burrowing cascade; Ecosystem engineer

Citation:
Kinlaw, A., Grasmueck, M., Evidence for and geomorphologic consequences of a reptilian ecosystem engineer: The burrowing cascade initiated by the Gopher Tortoise, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.06.030

Nine-banded Armadillo (*Dasypus novemcinctus)* Burrow Characteristics in Southern Alabama: Their Possible Zoogeomorphic Effects

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Burrowing animals act like a geomorphic disturbance, changing their environment through soil excavation, landform creation and bioturbation. The potential zoogeomorphic effects of these actions include modification of surficial features, increased soil erosion, changes in the growth and distribution of vegetation, and modifications to soil fertility. The burrowing nine-banded armadillo (*Dasypus novemcinctus)* migrated to North America prior to the 1850s and has since continued to expand their habitat to the American Southeast and parts of the Midwest. Little data are available on the zoogeomorphic impact of the burrowing nature of this species, making it difficult to predict future implications of this animal as it continues to migrate into new regions. On the University of South Alabama campus, in Mobile, Alabama, armadillos are present on a 35-hectare unprotected forested preserve used by the university community for outdoor activities and research. To understand the potential zoogeomorphic impact of armadillo burrows on the local environment, morphometric measurements were recorded on 187 burrows located in the study area. Using burrow entrance dimensions and minimum tunnel lengths in calculations, armadillos excavated approximately $0.029m^3$ to $0.04m^3$ of soil from each burrow. The entrances to burrows averaged 33.5º in slope and tended to be located in a microhabitat of a fallen tree, exposed tree roots, or a sideslope. Persistent forest litter fall and anthropogenic modifications make positive identification of spoil mounds possible in only over half of the burrow sites. Surface modification by armadillos is ongoing in the study area with over half of the burrows classified as active during the four-month project. We concluded that, for southern Alabama, armadillos prefer to excavate burrows into sideslopes, and that given the lack of ground cover, sandy soil, and humid climate, armadillos are an important zoogeomorphic agent.

Keywords: Burrows, Nine-banded armadillo, Zoogeomorphology, Southern Alabama

Citation:
Sawyer, C.F. et al., Nine-banded Armadillo (*Dasypus novemcinctus)* Burrow Characteristics in Southern Alabama: Their Possible Zoogeomorphic Effects, *Geomorphology* (2011), Forthcoming

Animal Foraging as a Mechanism for Sediment Movement and Soil Nutrient Development: Evidence from the Semi-arid Australian Woodlands and the Chihuahuan Desert

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An emerging area of interest in geomorphology over the past two decades has been the effects of biota on ecosystem processes. We examined the roles of a range of vertebrates on soil disturbance in two markedly different environments, the semi-arid woodland of eastern Australia and a Chihuahuan Desert grassland–shrubland in the south-western United States. Foraging pits of soil-disturbing vertebrates varied markedly from small scratchings of heteromyid (mainly *Dipodomys* spp.) rodents (1.8×10^{-4} m^3) to deep (1.0×10^{-2} m^3) excavations of the burrowing bettong (*Bettongia leuseur*) and greater bilby (*Macrotis lagotis*). Vertebrates moved substantial volumes of soil in both environments, and activity was highly temporally and spatially variable. At large spatial scales, soil disturbance by echidnas (*Tachyglossus aculeatus*) and Gould's sand goannas (*Varanus gouldii*) was substantially greater in communities dominated by shrubs, and where domestic livestock had been excluded. Heteromyid rodents tended to excavate more foraging pits in coarse-textured vegetation communities (both grasslands and shrublands). In both environments, foraging was concentrated close to perennial plants such as grass tussocks and tree canopies rather than in the interspaces. Foraging pits of Chihuahuan desert animals tended to be higher in labile carbon and support greater levels of infiltration, though this was plant community-dependent. Overall our results indicate that animal foraging is an important geomorphic mechanism capable of mobilizing substantial volumes of soil in arid and semi-arid environments and with potential effects on soil function.

Keywords: Foraging; Soil movement; Biopedturbation; Rodents; Vertebrates; Soil formation; Patchiness; Arid

Citation:
Eldridge, D.J., et al., Animal foraging as a mechanism for sediment movement and soil nutrient development: Evidence from the semi-arid Australian woodlands and the Chihuahuan Desert, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.04.041

Interactions Between Soil Biota and the Effects on Geomorphological Feature

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The interaction of animals with abiotic features of their environment has long been known to cause alterations to geomorphic features, and these interactions may cause feedback loops that further alter geomorphic features and animal communities. This paper samples the literature on selected burrowing animals in western North America, and discusses the interactions of animals with abiotic features of the environment and with each other, and the resulting impacts on geomorphic features and each other. As expected, burrowing characteristics of animals influence geomorphological processes. For example, pocket gophers and certain ground squirrels that burrow horizontal tunnels on sloping grounds seem to have significant impacts on horizontal movement of soils, whereas prairie dogs and harvester ants have more impact on vertical movement of soils. Burrowing animals, in general, increase the patchiness of the environment, which creates localized patch habitat for other plants and animals, thereby increasing biodiversity at the landscape scale. Burrowing animals influence and are influenced by microbes: sylvatic plague wiped out large populations of prairie dogs, earthworms cause major changes in soil microflora, pocket gophers and harvester ants cause changes in mycorrhizal communities, which in turn impact plant communities.

Keywords: Bioturbation; Soil creep; Patchiness; Soil nutrients; Burrows; Ecosystem engineering

Citation:
Zaitlin, B., Hayashi, M., Interactions between soil biota and the effects on geomorphological features, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.07.029

Post-speleogenetic Biogenic Modification of Gomantong Caves, Sabah, Borneo

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The Gomantong cave system of eastern Sabah, Malaysia, is well-known as an important site for harvesting edible bird-nests and, more recently, as a tourist attraction. Although the biology of the Gomantong system has been repeatedly studied, very little attention has been given to the geomorphology. Here, we report on the impact of geobiological modification in the development of the modern aspect of the cave, an important but little recognized feature of tropical caves. Basic modeling of the metabolic outputs from bats and birds (CO_2, H_2O, heat) reveals that post-speleogenetic biogenic corrosion can erode bedrock by between ~ 3.0 mm/ka (1 m/~300 ka) and ~ 4.6 mm/ka (1 m/~200 ka). Modeling at high densities of bats yields rates of corrosion of ~ 34 mm/ka (or 1 m/~30 ka). Sub-aerial corrosion creates a previously undescribed speleological feature, the apse-flute, which is semicircular in cross-section and ~ 80 cm wide. It is vertical regardless of rock properties, developing in parallel but apparently completely independently, and often unbroken from roof to floor. They end at a blind hemi-spherical top with no extraneous water source. Half-dome ceiling conch pockets are remnants of previous apse-fluting. Sub-cutaneous corrosion creates the floor-level guano notch formed by organic acid dissolution of bedrock in contact with guano. Speleogenetic assessment suggests that as much as 70–95% of the total volume of the modern cave may have been opened by direct subaerial biogenic dissolution and biogenically-induced collapse, and by sub-cutaneous removal of limestone, over a timescale of 1–2 Ma.

Keywords: Biogeomorphology; Biogenic corrosion; Apse flute; Bat; Swiftlet

Citation:
Lundberg, J., McFarlane, D.A., Post-speleogenetic biogenic modification of Gomantong Caves, Sabah, Borneo, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.04.043

Modern Warfare as a Significant Form of Zoogeomorphic Disturbance Upon the Landscape

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The damage exerted by warfare on the physical landscape is one, of many, anthropogenic impacts upon the environment. Bombturbation is a term that describes the impacts of explosive munitions upon the landscape. Bombturbation, like many other forms of zoogeomorphology, is a disruptive force, capable of moving large amounts of sediments, and denuding landscapes to the point where changes in micro and mesotopography have long-term implications. The long term implication of bombturbative actions depends on the type and duration of explosive device that rendered the disturbance, and the geographic context of the landscape disturbed; i.e. cultural and physical factors. Recovery from bombturbative activity, in the context of this research, is measured by vegetative regrowth and soil development in cratered disturbances. A comparison and contrast between the two battlefields of Verdun, France and Khe Sanh, Vietnam show that bombturbative actions have significantly altered the topography at each location, thus influencing surface runoff and processes of soil development. Principals of the Runge pedogenic model, or the energy of water moving through the soil profile, best explain how the varying climate and parent material at each location influence post disturbance soil development rates. Whereas the data collected at Verdun suggest that explosive munitions have put that landscape on diverging path of development, thus rendering it much different post-disturbance landscape, Khe Sanh displays much different recovery patterns. Preliminary research at Khe Sanh indicates that reforestation and soil development following disturbance are not so much influenced by bombturbative patterns as land use activities in the area of study.

Keywords: Zoogeomorphology; Bombturbation; Military geography; Pedogenesis

Citation:
Hupy, J.P., Koehler, T., Modern warfare as a significant form of zoogeomorphic disturbance upon the landscape, *Geomorphology* (2011), doi:10.1016/j.geomorph.2011.05.024

The Impact of Climate Change on Patterns of Zoogeomorphological Influence: Examples from the Rocky Mountains of the Western U.S.A.

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Many animals in the mountains of the western U.S.A. and elsewhere are geomorphically active. The spatial pattern and intensity of these impacts, associated with activities such as digging for food, burrowing for shelter, and damming of streams, may change as a result of climate change. Food sources utilized will be affected by processes such as meadow infilling with trees, upward advancement of trees, and changes in intensity of other geomorphic processes such as avalanching and glacial action and associated meltwater. Examples are presented here that illustrate the importance of accurate habitat mapping to be able to assess the impact of climate change on geomorphically active animals, as well as the importance of knowledge of food sources of these animals. As climate change impacts food sources and habitats, some geomorphically active animals may become much more limited in the geographic range and intensity of their influence, and some may disappear altogether if the habitat disappears.

Key Words: Zoogeomorphology; Rocky Mountains; Glacier National Park, Montana; Beaver; Grizzly bear; Pika; Climate change

Citation:
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Poster Abstracts

Gender and Ectosymbiont Influence on Burrow Excavation by the Red Swamp Crayfish (*Procambarus clarkii* Girard, 1852)

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Stream-dwelling crayfish have been demonstrated to be strong ecosystem engineers in some systems. Less is known about burrowing crayfish, although they have been shown to enhance soil aeration, nutrient cycling, and influence habitat heterogeneity as a result of their burrowing behavior. The factors influencing the size and complexity of burrows are also not well understood. In *Procambarus clarkii* (Girard, 1852), the strategy of prolonged brooding young in burrows by females could cause a different burrowing response compared to male individuals. Also, the presence of symbiotic Branchiobdellidae worms has been correlated with increased survivorship and growth in stream crayfishes, presumably as a result of worm grazing on epibionts of fouled crayfish gills. Preliminary trials with *P. clarkii* in Artificial Burrowing Chambers (ABC's) revealed a wide array of burrow sizes and morphologies. Thus, behavorial differences associated with gender or influence by ectosymbionts were tested as possible factors influencing this variation in burrow size and morphology. Growth, survivorship, burrow construction and volume were monitored on a total of 32 crayfish, 8 individuals per treatment of sex and presence or absence of worms using ABC's for 7 weeks. Field collections of *P. clarkii* revealed a mean density of 10 worms per adult, thus 10 worms were added to 8 females and 8 males. To ascertain fouling between treatments, we monitored ammonia, pH, and DO weekly. We hypothesized that females inoculated with branchiobdellid worms would show increased burrow excavation as compared to other treatments. Preliminary results suggest that branchiobdellid worms have no effect on *P. clarkii* burrow volume, but that females on average exhibited more extensive burrowing as compared to males. Gender differences in burrowing behavior in *P. clarkii* suggest an important role for female crayfish not only for recruitment, but as ecosystem engineers.

Keywords: Crayfish; Ecosystem engineers; Gender; Ectosymbionts

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Mapping Slope Failure Hazards and Their Impacts on Humans Structures in Grand Teton National Park, Wyoming

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Mass movement plays a significant role as a hazard in the deglaciated mountain canyons in Grand Teton National Park. The park's geologic and glacial histories are very unique in comparison to other areas in the Rocky Mountain range. However, few detailed maps and statistical analyses of mass movement as hazard exist for park officials and visitors. The purpose of this study is to produce a comprehensive map of slope failures in five main deglaciated canyons of the park: Granite, Garnet, Paintbrush, Cascade, and Death. This project used a combination of fieldwork and LiDAR imagery to group together four main categories of slope failures—rock slides, rock/debris flows, rock falls, and snow avalanches. Methods used to help differentiate types of mass movements include weathering, groundwater presence, elevation, slope

profile, joint spacing, joint orientation, joint width, and joint continuity, as well as rock mass strength as measured by a Schmidt rock hammer.

These slope failures not only impact the physical landscape of the canyons but can affect human structures as well. Physical attributes and locations of slope failures were compared to locations of camping zones and hiking trails in the Park to determine areas most susceptible to movement events.

Keywords: Mass movement; Slope failures; Geomorphologic mapping; Rock strength; Glacier characteristics, Human-environmental interactions

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Biogeomorphology and Physical Ecosystem Engineering: Fundamental Overlaps and Distinctions, and Opportunities for Conceptual Integration

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There has been considerable theoretical advancement in recent years of the ways in which organisms interact with the physical environment within both geomorphology and ecology; this is exemplified by the increasing interest and research activity in the sub-disciplines of biogeomorphology and ecosystem engineering. These two parallel fields have developed independently, and while the concepts, theories and terminologies of each are increasingly being cross-referred, biogeomorphologists and ecosystem ecologists have much to offer, and much to gain, from further aligning their research. Developing an integrated conceptual framework could prove a useful starting point.

We suggest that biogeomorphology and physical ecosystem engineering are essentially concerned with the same phenomenon – alteration of the abiotic (non-living) environment through biotic activity. The fundamental distinction between the two relates to where the focus of the outcomes of this interaction is placed; biogeomorphology has—for the most part—been concerned with the processes and rates of alteration of physical form by organisms, while the subsequent consequences of these changes for other organisms (and the original 'engineer') is the focus of physical (i.e. allogenic) ecosystem engineering. Alongside any direct consequences of such an interaction (whether landform alteration/creation in the case of biogeomorphology, or habitat alteration/creation in ecology for example), the activities of engineer species can give rise to complex and interacting biotic-abiotic feedbacks that may ultimately exacerbate (or dampen) the initial impacts over time, representing further indirect geomorphic and ecological consequences. We use the example of bioerosion on rocky shores to illustrate these complexities.

An underlying mutual concern with biologically-mediated change to the physical environment means that the organisms of interest to biogeomorphologists and ecosystem engineering ecologists, the methods used to study and evaluate their 'engineering' (or biogeomorphic) impacts in time and space, and the data collected by these two groups of researchers will very often be complementary.

Keywords: Biogeomorphology; Ecosystem engineering; Feedbacks; Integration; Conceptual frameworks

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Bioprotection in the Rocky Intertidal Zone: Evaluating the Micro-climatic Influences of Epibiota in Geomorphology and Ecology

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Epibiota influence the spatial and temporal variability of micro-climate on rocky shores, having important consequences for ecology through facilitative interactions that can be conceptualised under a framework of ecosystem engineering. At the same time, epibiota may influence the efficiency of deteriorative processes by modifying the weathering environment at the rock–air interface, but this has rarely been tested or quantified. Such interactions are expected to occur on artificial hard coastal structures (built from rock and concrete) as well as on natural rocky shore substrata, and may represent previously unrecognised ecosystem services (i.e. bioprotection).

We compared near-surface temperatures, humidity and moisture loss for coastal structures built from concrete and limestone in South West England, UK. Measurements were made in areas colonised by fucoid algae (seaweed) and adjacent cleared areas. Data was collected at 1-minute intervals during selected low tides, and continuously at 30-minute intervals over a 6 week period in summer 2011 using iButton® and TinyTag data loggers. Where possible, substratum moisture content was monitored at two depths (10mm and 25mm) using a capacitance moisture meter.

Temperatures were always lower, and humidity always higher, for colonised areas compared to cleared areas. The magnitude of these differences varied in the order of 2–9°C for temperature and 10–20% for humidity, depending on the timing of low tide during the day and local weather conditions. Materials showed evidence of drying during low tide, but moisture content was more stable under the algae canopy and deeper within the substratum.

Macro-algae buffered thermal extremes and suppressed the amplitude of short-term (i.e. minutes) fluctuations in climate parameters (temperature and humidity) at the surface of intertidal structures. This may reduce the efficiency of weathering associated with thermal fatigue, wetting–drying and salt crystallisation in hot, sunny weather. This must, however, be evaluated against potentially higher rates of chemical weathering associated with elevated humidity and water retention. In addition to any protective functions, the provision of cooler and wetter conditions by macro-algae is an example of ecosystem engineering—creating less stressful conditions for organisms that may otherwise experience mortality in summer—thereby contributing to the maintenance of biodiversity on artificial coastal structures.

Keywords: Bioprotection; Intertidal; Epibiota; Weathering; Physical ecosystem engineering

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Burrowing Rodents as Geomorphic Actors in Sub-polar and Alpine Environments – A Comparative Analysis

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The geomorphological impact of small fossorial rodents can be considerable, and both their direct and indirect effects may contribute to landscape formation. A comparison of the findings from field investigations by the author on sub-Antarctic Marion Island, South Africa and sub-Arctic Abisko, Sweden

with published data on seven other rodent species and other physical/chemical mass transfer mechanisms in sub-polar and Alpine environments suggests that fossorial rodents are a significant and sometimes dominant geomorphic force in these environments. The interplay between fossorial rodents and geomorphology can be conceptualized into: a. Bio-erosion - active or passive, mechanical erosion on land forms by burrowing, grazing or trampling. b. Bio-protection - the roles of prevention or reduction of the effect of other earth surface processes by e.g. manuring/fertilization, bioturbation and seed propagation. c. Bio-construction - the building of mounds, terraces or other landforms by material that is produced locally, bound together from other sources or developed in combination of the two. In Alpine and periglacial environments rodents can constitute a powerful geomorphic force, and in several of these environments, characterised by a high level of abiotic stress, they actively contribute to the creation of landforms, impacting the landscape on both micro and macro scale and keeping up biodiversity. The geomorphic work by ground squirrels, ice rats, plateau pikas and zokors is shown to be in the same order of magnitude as solifluction and rock falls. Thus they are considered to act as key-stone species and ecosystem engineers both through the creation of landforms by dislocation and of soil and also by other impacts on soil properties, vegetation and ecosystem function.

Keywords: Burrowing rodents; Alpine environment; Sub-polar; Bioprotection; Bioerosion

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Influence of Grazing Treatment on Stream Substrate and Channel Geometry in the Flint Hills, Kansas

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From 1940 to 1960 the number of cows in the United States increased by 60% while the acreage of private grazing land decreased by 15%. As a result there has been increased strain on private rangelands. Cattle grazing is a common land management practice throughout the United States and very prevalent in native remnants of Great Plains prairie grasslands. Cattle have a direct influence on stream morphology due to their summer grazing habits. Cattle graze near riparian vegetation due to water and food availability. Experimental grazing treatments at the Konza Prairie LTER represent an excellent opportunity to study stream channel response to grazing impacts. Twelve watersheds were evaluated in a paired watershed geomorphological assessment, with 3 grazed by native bison, 3 grazed by cattle, and 6 ungrazed watersheds, to enable cross-watershed comparative analysis to quantify how do stream morphology and sediment characteristics vary between ungrazed, cattle-grazed and bison-grazed watersheds. Geomorphological measurements included hydraulic geometry, pebble counts. Preliminary results show significant differences between grazing treatments on the geometry of the cross sections (width to depth ratio) while surface substrate does not vary significantly between treatments. This is the first study to investigate grazing impacts on Great Plains stream systems and is the first to compare the relative impacts of cattle versus bison grazing habitats. This research addresses the substantial gaps in knowledge regarding the fluvial geomorphic implications of grassland management in the Great Plains.

Keywords: Grazing; Cattle; Bison; Sediment; Channel geometry

Instream-Flow Science and Sediment Transport: A Difficult Integration of Multi-Disciplinary Approaches to Engineer the Future of Aquatic and Riparian Habitats in Texas

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Instream-flow science is a burgeoning interdisciplinary collaboration of hydrologists, biologists, engineers, geographers, geomorphologists, and water managers, which is designed to address physical and chemical requirements for sustainability of aquatic and riparian species. The "science" was borne of concerns by riparian biologists that aquatic species and their habitats have been drastically disrupted and fragmented by anthropogenic activities and barriers, notably dams and reservoirs on main-stem rivers. As such, efforts and policies have historically been guided by biological scientists, who have collectively adopted an approach to: (i) restore the natural flow regime, (ii) restore longitudinal and lateral connectivity, (iii) maintain acceptable levels of water quality, and (iv) maintain physical characteristics that define habitats of selected target species. The latter objective includes the domain of geomorphology, notably for associating known anthropogenic disturbances with modification of physical habitat structures (e.g., channel bars, pool-riffle sequences, oxbow lakes, etc.) and offering solutions to reverse undesirable process trajectories or remediate negative consequences. Despite the impressive promulgation of instream-flow programs and policies across the United States, the inclusion of sediment transport and geomorphic evaluations is notably lacking in many applied efforts. This poster shows how a "hydrology-alone" approach to establish instream flows in Texas falls well short of ensuring physical integrity of a main-stem river downstream from a large reservoir. Specifically, the Hydrology-Based Environmental Flow Regime (HEFR) model was used to derive a plausible instream-flow prescription for the sand-bed Sabine River near Bon Wier, Texas (USGS 08028500), based on pre-regulation flow conditions (1924–1960). The Engelund-Hansen bed-material transport model was applied in the SAM Hydraulic Design Package for Channels to determine annual sand loads for measured and modeled flows. Notably, the average annual water yield is reduced by 56% and the average annual sediment yield is reduced by 67% for HEFR-prescribed flows, as directly compared to observed flow conditions between December 1971 and November 2007.

Keywords: Instream-flow science; Sediment transport; Sabine River, Texas

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The 44th Binghamton Geomorphology Symposium: Coastal Geomorphology and Restoration

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The need to understand the complex interactions of geomorphic, biotic and human processes on beaches and dunes is growing in importance due to predictions of increases in relative sea level rise, storm

activity and population density. These stressors will likely have dramatic effect on the resilience of coastal systems and the ultimate success of future management strategies to cope with community hazards. Advances in research within biology and earth sciences have increased our understanding of the interactions between coastal flora/fauna and geomorphic changes in nearshore, beach and dune environments. There is still a need for a synthesis approach that will more fully describe development, feedback, and maintenance of coastal systems over space and through time. Knowledge of biogeomorphic interactions on coasts that have been artificially restored or urbanized is still rudimentary, despite the efforts of many investigators from the physical, natural and social sciences who study coastal ecosystems across broad spatial and temporal scales. The three-day symposium is designed to present current knowledge and provide the opportunity to discuss future research directions on coastal systems, including models of system change and adaptive management. The symposium will be held at New Jersey Institute of Technology in October of 2013. Eighteen symposium presentations will be distributed across three sessions focusing on: (1) response of beaches and dunes to episodic events; (2) geomorphic and biologic processes and interactions in beach and dune systems on undeveloped and developed coasts; and (3) ability of coastal management and restoration practices to maintain or enhance landform and ecosystem functions and services.

Keywords: Coastal geomorphology; Episodic events; Coastal habitats; Coastal restoration

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Biogeomorphic Characterization of Coupled Dynamics in Geomorphology and Vegetation across Salt Marsh Creeks

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Geomorphic processes are often considered potential factors of vegetation succession. This research investigates whether and to what degree geomorphic processes and succession are intertwined in a salt marsh creek system. It is hypothesized that sites closer to the channels experience more dynamic changes in geomorphology, and hence, more changes in plant species composition than those farther away from the channels.

In the summer of 2006, ten newly-developing point bars and eleven relatively “fresh” (i.e. not significantly eroded) cutbank edges were selected at Skallingen in Denmark. Each location was subdivided into three levels. Level 1 was adjacent to the creek, having the greatest geomorphic change. Level 3 was 3-4 meters away from the channel on average, experiencing the least dynamics in fluvial geomorphology among the three levels. Level 2 represented approximately the midpoint between the other two levels. In each level, two replicate square quadrats (1 m2) were established to estimate the frequency of vascular plant species present. The same survey was performed at the same locations in the summer of 2011. Nonmetric multidimensional scaling was employed for the floristic data. In the resultant diagram, the Euclidean distance between two quadrats representing the same location but two different time period provides a quantitative estimate of the degree of ecological succession.

Results of analysis of variance indicated that, at neither point bar nor cutbank parts, there was any significant difference in the mean Euclidean distances identified from three levels. This implies that succession has proceeded at similar rates regardless of the distance to the channels, and therefore, whether geomorphic dynamics have been intensive or not (i.e. hypothesis rejected). Such similar rates probably result from allogenic and autogenic processes that dominate sites close to and away from the creeks, respectively. In Level 1, dynamic fluvial-geomorphic processes have driven retrogressive succession, while progressive succession has occurred in Level 3 due to decreased bar sedimentation and bank erosion.

This research elucidates not only that coupled geomorphic and floristic dynamics do exist in the marsh system studied, but also that such a coupling may weaken where the direct influence of fluvial-geomorphic processes is reduced.

Keywords: Convergence; Cutbank; Fluvial-geomorphic processes; Point bar; Succession

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Facilitate Migration of Coastal Habitats in Response to Rising Sea-levels: An Adaptation Strategy for National Coastal Parks

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Global warming and accelerated rates of sea level rise, combined with inability of coastal landforms to migrate landward due to human infrastructure, will compress the space within which coastal habitats can exist. Landforms and habitats must have the ability to reform in response to storm damage and increase their capacity for long-term sustainability. Shoreline stabilization structures (including bulkheads, sea-walls and groins) can all impede natural sediment transport processes and serve as barriers to landform migration. Removal or modification of these structures provides the opportunity for natural restoration of coastal landforms and habitats. The National Park Service is evaluating how a coastal park climate change adaptation strategy can be implemented to allow natural shoreline processes to prevail with rising sea levels. The first component of this evaluation is a field investigation conducted at Sandy Hook Spit in Gateway National Recreation Area to identify the functions of all shoreline stabilization structures and the opportunities to facilitate landform migration by removing the structures or allowing them to deteriorate. Results indicate that (1) there is little need to take immediate action where protection structures are in good condition and protect buildings and infrastructure that are still in use; (2) there are many other locations where changes in land use priorities make protection structures irrelevant; (3) the accommodation space for development of new landforms can be found alongshore as well as onshore, so new habitat can be created by loss and re-creation in a different location, not just by landward migration; and (4) removing structures creates options for landforms and habitats that differ from those that would occur if structures are allowed to deteriorate. Implementing small-scale accommodation strategies by eliminating structures that are now considered unnecessary or marginal will establish precedents to facilitate more difficult future decisions.

Keywords: Beach erosion; Coastal habitats; Sea level rise; Sustainability

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Termites vs Large Herbivores as Ecosystem Engineers across African Savanna Landscapes

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Understanding the interactive impacts of different ecosystem engineers on species across landscape is crucial for guiding conservation and management of biodiversity. Termites and large herbivores are prominent ecosystem engineers in African savannas that significantly influence biodiversity patterns across the landscapes. Little however, is known about their interacting roles. To examine interactive impact of termites and large herbivores on herbaceous diversity, we conducted a field experiment in Lake Mburo National park, Uganda where large-mound building termites (Macrotemes) and large herbivores both are common ecosystem engineers across the landscapes. We found that termites other than large herbivores enhanced herbaceous diversity and richness. The lack of interactive effects of termites and large herbivores on diversity suggests that below-ground resource control appear to be the primary mechanism by which ecosystem engineers modulate diversity. Our result offers a noble mechanism for understanding the dependency of diversity on ecosystem engineers with vast implications for conservation of biological diversity in African savannas.

Keywords: Termites; Herbivores; Uganda; Ecosystem engineers

Sediment Preference during Excavation and Construction of Chimneys by *Cambarus diogenes*

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As ecosystem engineers, burrowing crayfish alter their surroundings through burrowing, soil excavation, and chimney construction. Little is known about the behavior of these specialized crayfish as much of their life history takes place in subterranean burrows. Field observations of chimney excavations and colony sites indicate an affinity for burrowing in clay rich soils. In this study, we investigate soil selectivity during active burrowing and chimney construction. *Cambarus diogenes,* a widespread and highly abundant primary burrower was used as the trial species. Artificial burrowing chambers (ABC's) were used to investigate burrowing preferences. Chambers were filled with three horizontal substrate bands: a top band of ambient soil collected near natural crayfish colonies, a center band split in half with clay on one side and sand or 1:1 sand/ambient soil on the other, and a bottom band with ambient soil. Crayfish where induced to burrow down the center of the chamber until they encountered a substrate choice (clay vs. other). The majority of burrow excavation and chimney construction (90.8%) occurred within the initial three days. Preference to soil type was quantified by measuring the horizontal length burrowed into each sediment at the groundwater level. These values where converted to a percent of excavation of total seam width. Preliminary studies show that *C. diogenes*, when given a choice to burrow in clay or 1:1 ambient/sand chose to excavate 72.5% ± 33.15 of total sediment distance in clay compared to 24.5% ± 18.26 in 1:1. When sand was offered, *C. diogenes* burrowed 66.48% ± 22.86 of the total clay distance compared to 28.52% ± 26.73 of the total sand seam distance. This preference to burrow in clay influences the surrounding environment by increasing soil heterogeneity by releasing organic matter and increasing associated clay particles in the adjoining sediment profile.

Key Words: Sediment preference; Crayfish; Ecosystem engineer; Chimney construction

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Phytogeomorphic Influence of Sedimentology and Slope Processes on Talus Vegetation in the Southern Cascades, California

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The vascular vegetation of talus slopes was examined in Lassen Volcanic National Park (California Cascades) at 2035-3095 m. Taluses show a diverse flora, with 79 plant species; growth forms include trees, shrubs, suffrutices, herbs, graminoids, and ferns. Plant patterns were studied along 40 point-intercept transects; plant cover was low (0-32.7%) on all slopes, spatially variable, and showed no consistent trends. Sedimentological characteristics were determined by photosieving near 1500 plants; this census indicated preferential plant growth on blocks and cobbles, with 43.2% and 23.3% of plants growing on these, respectively; fewer specimens were rooted on pebbles (13%) or on stone-free gravel areas (20.5%). Growth forms displayed different substrate preferences: 92.5% of shrubs and 83% of suffrutices colonized blocks or cobbles, but only 57.2% of herbs and 59.8% of graminoids grew on large stones. Plants are associated with clasts because (1) coarse talus is more stable than fine sediment areas, more frequently disturbed by various geomorphic processes; and (2) large stones help conserve water beneath them while moisture quickly evaporates from fine debris.

Root patterns were studied for 30 plant species; 10 specimens per species were excavated and inspected, and several root growth ratios calculated. All species exhibited pronounced root asymmetry, as roots for most plants grew upslope from their shoot base. For 23 species, all specimens had 100% of their roots growing upslope; for 7 species, 92.2-99.3% of belowground biomass extended uphill. Uneven root distribution is ascribed to continual substrate instability and resulting *talus shift*; as cascading debris progressively buries roots and stems, plants are gradually pushed and/or stretched downhill. Various disturbance events affect root development. Slope erosion following rubble removal often exposes plant roots. Debris deposition can completely bury plants; some survive sedimentation, producing new shoots that grow through accumulated debris. Shrubs may propagate by layering, as adventitious roots develop along buried stems; or produce new clones along their roots. Slope processes can damage and transport plant pieces downhill; some species sprout from severed, displaced root or stem fragments. Vegetation interacts with several geomorphic processes, including rockfall, debris flows, grain flows, snow avalanches, and runoff.

Keywords: Alpine vegetation; Biogeomorphology; Root patterns; Sedimentology; Talus processes

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Logjams and Avulsions in the San Antonio River Delta: Cause-and-Effect, or Effect-and-Cause?

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Avulsions and logjams are both common in the San Antonio River Delta area, Texas, including at least four avulsions in the past 80 years and a 3 km long logjam that persistently reforms at the site of an ongoing avulsion from the San Antonio River into Elm Bayou. Logjams and large woody debris (LWD) are known to deflect flows and trigger avulsions, and local avulsions associated with flow displacement by logjams were observed in the study area. LWD and logjams are most likely significant in some past

avulsions in the delta. However, the history of the San Antonio/Elm Bayou split and logjam(s), and reaction to both removal and re-formation of the jam, shows that logjams are not responsible for the avulsion. Logjams form repeatedly in the Elm Bayou area because the narrow channels allow large floating logs or uprooted bank trees to become jammed and form anchors for LWD accumulation. The narrow channels exist because avulsions form a multi-channel flow pattern, with narrower channels than the single channel upstream. Thus in this case—and most likely some others, too—avulsions indirectly trigger logjams, rather than vice-versa.

Keywords: Avulsions; Logjams; Large woody debris; San Antonio River Delta

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Path Stability of Biogeomorphic Transitions

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Existing stability concepts in geomorphology and ecology address *resistance* (mechanical stability) and *resilience* (dynamical stability). To understand sequences or trajectories of change in biogeomorphic systems a third aspect of stability must be assessed: *robustness,* the ability to maintain a developmental sequence or pathway. Changes in the state of geomorphic and ecosystems are first represented as state-and-transition, evolution, or box-and-arrow models, or as signed digraphs. Path stability is then based on the adjacency matrix of these state transition networks, using methods adapted from analysis of dynamical stability and from spectral graph theory. Path stability is determined for several archetypal cases, such as classic succession and channel evolution models, and for the case of fluviokarst landscapes and associated ecosystems in central Kentucky.

Keywords: Path stability; State transitions; Biogeomorphic systems; Spectral radius

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Impacts of Biological Invasions on Geomorphology

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Invasive exotic species (IES) pose a significant threat to the health and longevity of many natural ecosystems. Given the tightly-coupled recursive relationships that sometimes exist between biota and geomorphological processes, this raises the question of the potential geomorphic impacts of IES, and the role of biogeomorphic phenomena in ecological changes associated with IES. Recent studies have suggested that certain IES have the capacity to modify the geomorphology of their host environment. This novel geomorphic change could have dire consequences for ecosystem form and function. The purpose of this research is to create a comprehensive review to integrate three distinct groups of literature, on invasive species, ecosystem engineers and niche construction, and on biogeomorphology. While the invasive species literature has recently begun to address ecosystem engineering, no explicit consideration of invasive impacts on Earth surface processes and landforms has been undertaken. And while biogeomorphologists have recognized the ecosystem engineer concept as a framework for connecting ecological and geoscience studies, biogeomorphology has not yet been linked to invasive species

phenomena. This review therefore represents a unique and important synthesis. One goal for this synthesis is to develop a concept of landscape metamorphosis triggered by biological invasions and/or geomorphic disturbances and accomplished via mutual interactions of geomorphic and ecological processes. Synthesizing these literatures will help to better understand the impact of invasive species on ecosystem structures and processes from a geomorphological perspective, facilitate the incorporation of geomorphic impacts into invasive species management, and provide insight and directions on the development of biogeomorphology.

Keywords: Biogeomorphology; Invasive exotic species; Ecosystem engineering

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Biogeomorphic Domains, Functional Diversity, and Stability in Natural and Human-Modified Barrier Islands Dunes

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My earlier research used resiliency theory as a framework to conceptualize the dynamics of biogeomorphic activity. I posited how two geomorphically dissimilar barrier island dune systems in Georgia (GA) and North Carolina (NC) can be considered stability domains. Field data corroborated that each island has its own distinctive plant and animal-mediated topographies that may reinforce habitat conditions, species abundances, and patterns of sediment mobility associated with overwash in a positive feedback. However, additional theoretical and observational evidence is warranted, especially in regard to how the underlying patterns of species abundances confer resiliency.

The textural discontinuity hypothesis makes suppositions about how the abundances of organisms could be expected to vary within and between stability domains. It holds that for the feedbacks that make biogeomorphic stability domains persist, only a subset of geomorphic functional types, or driver species, may be required. Higher species diversities might contain the full suite of functional types. But they would be less supportive of the specific operative biogeomorphic feedbacks conferring resiliency in a particular geomorphic setting. We present field data to support this. Higher species diversity developed where the prevailing patterns of sediment mobility on each island departed from the historic precedent. The full suite of functional species was not encountered. Such an assemblage may result in idiosyncratic resiliency properties since overwash contagion cannot be simultaneously reinforced (NC) or diminished (GA).

We integrate these findings into an old, but still useful heuristic, the Intermediate Disturbance Hypothesis, to convey how higher diversities along a disturbance gradient may be more transient and less likely to organize predictably into a resilient domain configuration. However, a greater number of islands need to be sampled and characterized in terms of topography and plant abundances. Visualization and statistical mapping of this larger biogeomorphic state space may provide visual, exploratory evidence as to how stability, species diversity, functional diversity, and plant functional types covary. Islands modified by humans would also be useful to include. These islands should have a greater range of species diversity, from transient systems consisting of the full suite of functional types, to those that are dominated by a single species.

Keywords: Stability; Diversity; Barrier islands; Dunes; Human impacts

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Biotic Influence on Peatland Stream Channel Morphology

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This study assessed the role of biotic factors on channel planform and morphology of the Cranberry River as it flows through a southern Appalachian Mountain peatland complex in West Virginia, USA. Vegetation, beaver dams, and fluvial wood have been found to impart strong influence on northern peatland stream channel morphology. Wetland streams contain different morphologies compared to alluvial streams; however, few studies have been performed on wetland, and particularly peatland, stream geomorphology. The Cranberry River displays distinctly angular bends, and others have attributed angular bends in northern peatland streams to biotic factors. Field data were collected on channel morphology and planform pattern in relation to beaver dams, riparian vegetation, and the presence of wood along 48 cross–sections within a 2,000 m reach of the Cranberry River. Morphological characteristics, including longitudinal bankfull width pattern, width/average depth ratio, and thalweg location, were similar to those found in other wetland streams. Average water depth of beaver ponds was 0.46 m (n = 5) upstream of the dams, compared to 0.32 m (n = 33) on undammed sections, and average bankfull width was greater 10 m upstream and downstream of the dams (9.5 m and 7.0 m, respectively) than in undammed sections (6.6 m). Sediment composition and water depth immediately downstream of wood within the channel differed from areas with no wood. Riparian vegetation was predominantly *Alnus rugosa* (speckled alder) and varied little along the length of the studied section of the Cranberry River, and no relation was found between riparian vegetation and channel form. Though dams and wood influenced channel morphology, the effects were limited to areas in immediate association with the features. Biotic factors did not appear to exert significant influence on overall channel pattern or be responsible for the angular channel morphology. The geomorphic history and setting of this study area are different from those of northern peatlands and may have strong influence on the current form of the Cranberry River. The findings of this study add to the scant literature on southern peatlands and wetland stream geomorphology, and emphasize the need for better understanding of southern mountain wetland processes for restoration and management purposes.

Keywords: Appalachian peatlands; Beaver dams; Riparian vegetation; Wetland streams; Fluvial geomorphology

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Annual Mud and Clast Transport Rates by Cave Swallows (*Petrochelidon fulva*) at a Controlled Nesting Site in Central Texas

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The cave swallow (*Petrochelidon fulva*) is one of three mud-nesting swallows that colonize in Central Texas. The cave swallow migrates southward to South America during the months of October/November to March/April and will nest and brood during the summer months in small regions of Central Texas. Over recent decades, the cave swallow has been found nesting in artificial structures, when they were once restricted to caves and other natural environments. The Alkek parking garage on campus at Texas State University-San Marcos is one artificial nesting location for cave swallows. This site has been colonized for several years and has been a nuisance for the faculty, staff, and students who park there. The parking commission had decided to remove all nests prior to the cave swallows' return for summer breeding in March 2011. The efforts to deter the cave swallows from returning were unsuccessful, posing an excellent site for zoogeomorphic research. Since all previously existing nests were removed before the return of the swallows, the amount of nests constructed during one summer was specifically analyzed. In addition, the individual mass of a cave swallow nest is known from sampling at this specific site previously and was applied to the number of new nests constructed to calculate the total amount of soil material transferred to a cave swallow community in one summer.

Keywords: Avian; Cave swallow; Nesting; *Petrochelidon fulva;* Zoogeomorphology

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Terracette Genesis and Related Ungulate Activities in Western Pottawattamie County, Iowa

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Terracettes are small, quasi-parallel, staircase-like, stepped landforms. They are generally less than a meter in tread width and riser height and as long as 300 meters, located transversely along slopes. Many theories purport to explain the mechanisms that cause them, including animal disturbance, soil creep, solifluction (gelifluction), slumping and rotational slippage, regolith control, vegetation control, subsidence, and anthropogenic or tectonic activities. This study was aimed at morphologically characterizing terracettes in the western Iowa Loess Hills using repeat photography and other morphometric analyses. Preliminary observations of recently graded slopes suggest that terracettes in this area are caused by anthropogenically induced grazing of domestic ungulates such as cattle and horses, as well as wild deer, because new terracettes have developed in less than one season since the slopes were cleared. These new, low-order terracettes are directly related to ungulate activities such as geophagy, soil transport (from hooves), compaction, smearing, pawing, and wallowing (dust bathing) as well as the effects of variable soil moisture on erosion of the forms used by the animals.

Keywords: Geophagy; Terracettes; Ungulates; Loess Hills; Wallowing

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Processes Responsible for Solifluction Tread and Riser Deterioration in Glacier National Park, Montana

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Solifluction treads and risers are common periglacial features in alpine environments and much research has highlighted the characteristics of these landforms. Few studies, however, have examined the processes by which solifluction treads and risers degrade. In Glacier National Park, Montana, relict treads and risers are typically found on northern aspects in alpine environments and appear to be deteriorating by both physical (e.g. turf exfoliation, rockfall) and biological (e.g. tree establishment, fossorial mammal activity) processes. We observed that south-facing cliffs susceptible to extreme freeze-thaw cycles resulted in substantial rockfall that disrupted east-facing solifluction treads and risers. Conversely, treads and risers on northern aspects appeared to be dominated by biological erosional processes. Previous research confirmed that conifer seedling establishment, primarily whitebark pine (*Pinus albicaulis*), often occurred in north-facing solifluction risers and can ultimately result in tree islands that disrupt treads and risers and alter soil conditions. In addition to seedling establishment, animal diggings occur within treads and risers. We measured 60 excavations in which 1.17 m^3 of soil were removed from solifluction risers over a two-year period. Supporting evidence suggests that grizzly bears are responsible for these diggings and excavation densities can be as high as 57 per 30 m quadrat. Additionally, Columbian ground squirrel (*Spermophilus columbianus*) burrows were noted within vegetated risers and undoubtedly are responsible for additional degradation of solifluction features. Our findings suggest that biological erosional processes are substantial agents of solifluction tread and riser erosion over short temporal periods in an environment of apparent landform stability.

Keywords: Glacier National Park, Montana; Solifluction; Alpine environment

2011 BGS Student Fellowships

Catlin W. Ames	Auburn University
Donald Brinkman	University of South Alabama
Will Butler	Kansas State University
Tyler Covington	University of South Alabama
Bert Eriksson	Uppsala University
Bartosz Grudzinski	Kansas State University
Sarah Hosford	University of New Haven
Paul Okullo	Norwegian University of Life Sciences
Ian Palmer	Auburn University
Michael Shouse	University of Kentucky
Melanie B. Stine	Texas State University-San Marcos
Stephen G. Tsikalas	Texas State University-San Marcos
Elizabeth Stienstraw	University of South Alabama
Brandon Jeffery Weihs	Kansas State University
Clayton J. Whitesides	Texas State University-San Marcos

Binghamton Geomorphology Symposium History

The BGS is the oldest annual geomorphology meeting in North America. In 1966 four geomorphologists and physical geographers at the State University of New York (SUNY)-Binghamton, all graduates of A.N. Strahler at Columbia University, began organizing weekly "brown-bag lunches" and discussing informally about 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.

Rather than attempting to include all facets of geomorphology each year, the BGS is annually organized around a single theme. The original idea for the symposium was to emphasize the interdisciplinary nature of geomorphology, particularly for environmental geomorphology. Within several years, and with the addition of the late Marie Morisawa in 1970, the annual symposium quickly emerged as the preeminent North American geomorphology venue. The first BGS edited volume, entitled "Environmental Geomorphology", was published in 1970.

1. **Environmental Geomorphology**, D.R. Coates, 1970; Binghamton, NY
2. **Quantitative Geomorphology**, M. Morisawa, 1971; Binghamton, NY
3. **Coastal Geomorphology**, D.R. Coates, 1972; Binghamton, NY
4. **Fluvial Geomorphology**, M. Morisawa, 1973; Binghamton, NY
5. **Glacial Geomorphology**, D.R. Coates, 1974; Binghamton, NY
6. **Theories of Landform Development**, W.N. Melhorn & R.C. Flemal, 1975; Binghamton, NY
7. **Geomorphology and Engineering**, D.R. Coates, 1976; Binghamton, NY
8. **Geomorphology in Arid Regions**, D.O. Doehring, 1977; Binghamton, NY
9. **Thresholds in Geomorphology**, D.R. Coates & J.D. Vitek, 1978; Binghamton, NY
10. **Adjustments of the Fluvial System**, D.D. Rhodes & E.J. Williams, 1979; Binghamton, NY
11. **Applied Geomorphology**, R.G. Craig & J.L. Craft, 1980; Kent, OH
12. **Space and Time in Geomorphology**, C.E. Thorn, 1981, Urbana-Champaign, IL
13. **Groundwater as a Geomorphic Agent**, R.G. LaFleur, 1982; Troy, NY
14. **Models in Geomorphology**, M.J. Woldenberg, 1983; Buffalo, NY
15. **Tectonic Geomorphology**, M. Morisawa & J.T. Hack, 1984; Binghamton, NY
16. **Hillslope Processes**, A.D. Abrahams, 1985; Buffalo, NY
17. **Aeolian Geomorphology**, W.G. Nickling, 1986, Guelph, Ontario, Canada
18. **Catastrophic Flooding**, L. Mayer & D. Nash, 1987, Oxford, Ohio
19. **History of Geomorphology**, K.J.Tinkler, 1988, St. Catherines, Ontario
20. **Appalachian Geomorphology**, T.W. Gardner & W.D. Sevon, 1989, Carlisle, PA
21. **Soils and Landscape Evolution**, P.L.K. Knuepfer & L.D. McFadden, 1990; Binghamton, NY
22. **Periglacial Geomorphology**, J.C. Dixon & A.D. Abrahams, 1991, Buffalo, NY
23. **Geomorphic Systems**, J.D. Phillips & W.H. Renwick, 1992; Oxford, OH
24. **Geomorphology: The Research Frontier and Beyond**, J.D. Vitek & J.R. Giardino, 1993; Hamilton, Ontario
25. **Geomorphology and Natural Hazards,** M. Morisawa, 1994; Binghamton, NY
26. **Biogeomorphology, Terrestrial and Freshwater Systems**, C.R. Hupp, W.R. Osterkamp, & A.D. Howard, 1995, Charlottesville, VA
27. **The Scientific Nature of Geomorphology**, B.L. Rhoads & C.E. Thorn, 1996; Urbana-Champaign, IL
28. **Changing the Face of the Earth: Engineering Geomorphology**, J.R. Giardino, R.A. Marston & M. Morisawa, 1997; Bologna, Italy

29. **Coastal Geomorphology**, D.J. Sherman, P.A. Gares, 1998, Woods Hole, MA
30. **Geomorphology in the Public Eye**, P. Knuepfer & J.F. Petersen, 1999; Binghamton, NY
31. **Modeling and Geomorphology**, J.F. Shroder & M.P. Bishop, 2000, Binghamton, NY
32. **Mountain Geomorphology - Integrating Earth Systems**, D.R. Butler, S.J. Walsh, & G.P. Malanson, 2001; Chapel Hill, NC
33. **Dams and Geomorphology**, P.J. Beyer, 2002; Bloomsburg, PA
34. **Ice Sheet Geomorphology**, P.L.K. Knuepfer, J. Fleisher & D.R. Butler, 2003; Binghamton, NY
35. **Weathering and Landscape Evolution**, A.V. Turkington, J.D. Phillips, & S.W. Campbell, 2004; Lexington, KY
36. **Geomorphology and Ecosystems**, C.S. Renschler, M. Doyle, & M. Thoms, 2005; Buffalo, NY
37. **The Human Role in Changing Fluvial Systems**, W.A. Marcus & L.A. James, 2006; Columbia, SC
38. **Complexity in Geomorphology**, M.A. Fonstad & A.B. Murray, 2007; Durham, NC
39. **Fluvial Deposits and Environmental History**, P.F. Hudson, K.W. Butzer, & T.P. Beach, 2008; Austin, TX
40. **Geomorphology & Vegetation: Interactions, Dependencies, & Loops**, W.C. Hession, T.M. Wynn, J.C. Curran, & L.M. Resler, 2009; Blacksburg, VA
41. **Geospatial Technologies and Geomorphological Mapping**, L.A. James, M.P. Bishop, S.J. Walsh, 2010; Columbia, SC.
42. **Zoogeomorphology and Ecosystem Engineering**, D.R. Butler & C.F. Sawyer, 2011, Mobile, AL

Future scheduled symposiums:

43. **The Field Tradition in Geomorphology**, R.A. Marston, 2012, Jackson Hole, WY
44. **Coastal Geomorphology and Restoration**, N. Jackson, K. Nordstrom, R. Feagin, & W. Smith, 2013, Newark, NJ

Binghamton Geomorphology Symposium Steering Committee

Proposals for Binghamton Symposia are reviewed and accepted or rejected by the Binghamton Steering Committee. The Steering Committee may recommend changes in the program emphasis, speakers to invite to the conference, or other ways to improve the symposium. The Steering Committee also sets policy regarding the structure of meetings and, when necessary, steps in help with meeting management and publication of proceedings. The steering committee has long-term members, as well as rotating members.

Long-term members:

David Butler (Chair), Geography, Texas State University-San Marcos, Book Review Editor for *Geomorphology*
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Larry Davis, Earth and Environmental Sciences, University of New Haven
Carol Harden, Geography, University of Tennessee
Pete Knuepfer, Geology, SUNY at Binghamton
Richard Marston, Geography, Kansas State University, Co-Editor-in-Chief for *Geomorphology*
Jonathan Phillips, Geography, University of Kentucky
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Ellen Wohl, Geosciences, Colorado State University
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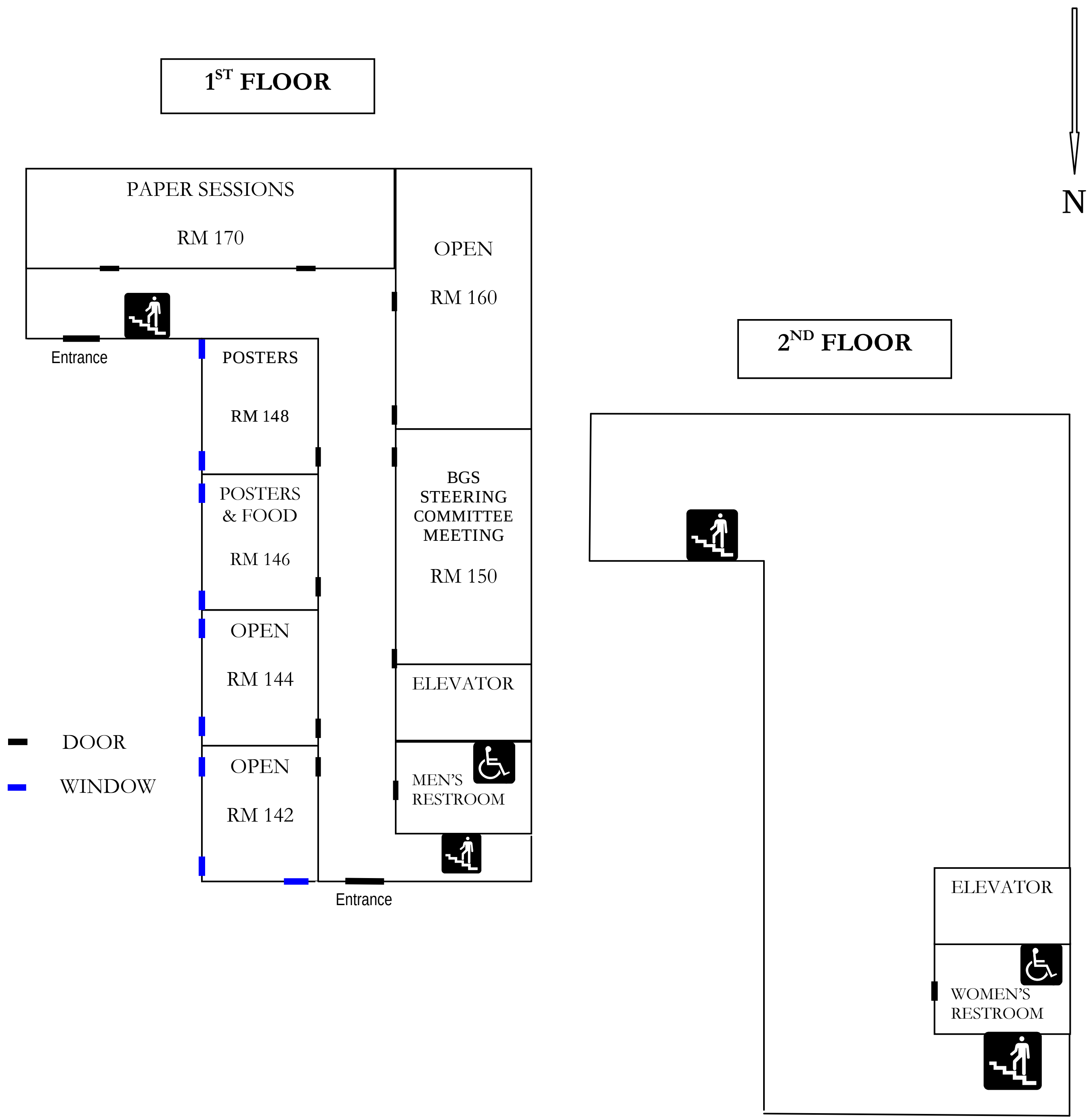
2007 - 2011: William Hession (Virginia Tech), Tess Wynn (Virginia Tech), Joanna Curran (Virginia), & Lynn Resler (Virginia Tech)
2008 - 2012: Michael Bishop (University of Nebraska), Allan James (University of South Carolina), Stephen Walsh (University of North Carolina-Chapel Hill)
2009 - 2013: Carol Sawyer (University of South Alabama)
2011 - 2015: Russell Feagin (Texas A&M University), Nancy Jackson (New Jersey Institute of Technology), Karl Nordstrom (Rutgers University), William Smith (Wake Forest University)

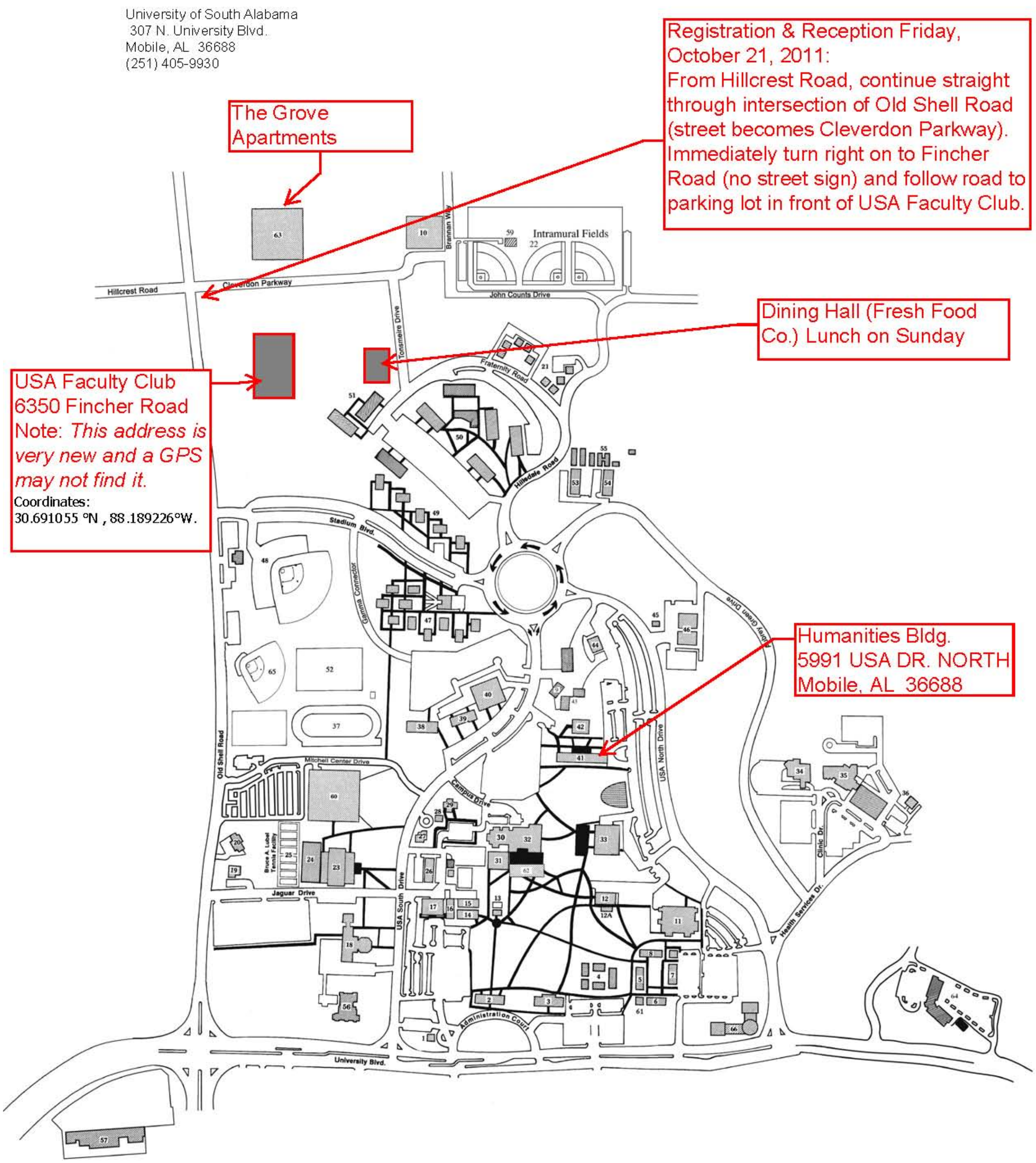
Index – Name

Index – Keywords

Map of Humanities Building – South



Campus Map



University of South Alabama
307 N. University Blvd.
Mobile, AL 36688
(251) 405-9930
The Grove Apartments
Registration & Reception Friday, October 21, 2011:
From Hillcrest Road, continue straight through intersection of Old Shell Road (street becomes Cleverdon Parkway). Immediately turn right on to Fincher Road (no street sign) and follow road to parking lot in front of USA Faculty Club.
Dining Hall (Fresh Food Co.) Lunch on Sunday
USA Faculty Club
6350 Fincher Road
Note: *This address is very new and a GPS may not find it.*
Coordinates:
30.691055 °N , 88.189226°W.
Humanities Bldg.
5991 USA DR. NORTH
Mobile, AL 36688
Intramural Fields
Hillcrest Road
Cleverdon Parkway
John Counts Drive
Brannan Way
Tonsmaire Drive
Fraternity Road
Hillsdale Road
Stadium Blvd.
Gamma Connector
Old Shell Road
Mitchell Center Drive
Campus Drive
USA South Drive
USA North Drive
Jaguar Drive
Administration Court
University Blvd.
Health Services Dr.
Clinic Dr.

2011 BGS Local Map